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SEMCON: A SEMICONDUCTOR DAMAGE DATA REDUCTION COMPUTER CODE.(U)

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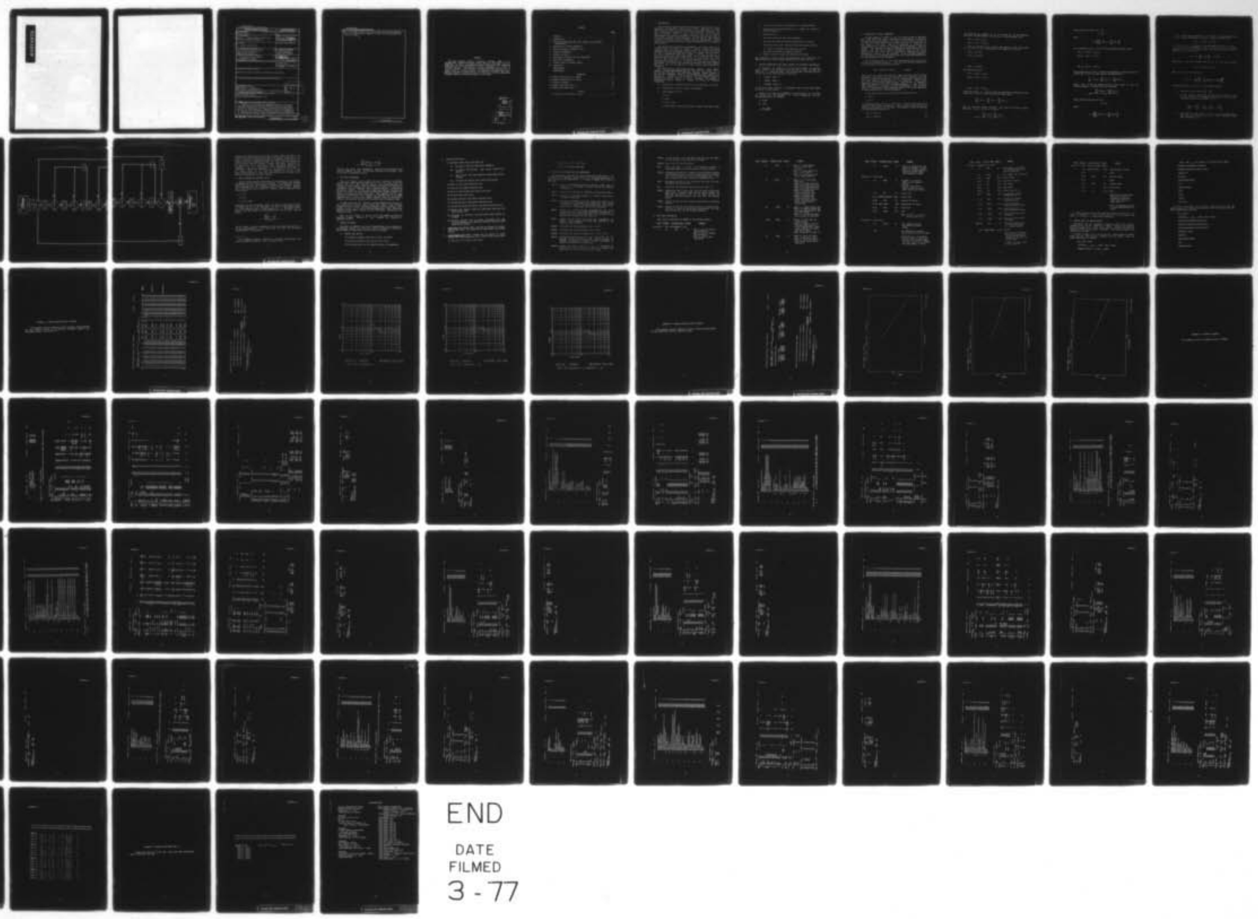

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SEMCON is a semiconductor damage-data-reduction computer code that analyzes various semiconductor devices. The code evaluates semiconductor devices by giving the following information: (1) determination of damage--the failure or nonfailure of a device; (2) calculation of power, energy, and impedance; (3) least-squares fits of specific damage curves to chosen data; (4) selection of the best least-squares fit; and (5) log-log

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plots of least-squares fits. This report details the development and capabilities of SEMCON, as well as the procedures for using the code.

FOREWORD

The Army Multiple Systems Evaluation Program (MSEP) is a comprehensive program developing general analytic techniques for the prediction of high electromagnetic-pulse vulnerability and hardening technology and for the application of these techniques to a list of critical systems. The analytic techniques have been verified for a large class of tactical systems. The hardening techniques have been applied to specific systems and are now resulting in product improvement programs leading to hardened equipment in the field.

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FIGURE

1. INTRODUCTION

This effort was written under the sponsorship of the Multiple Systems Evaluation Program (MSEP), which has as its main objective to harden Army tactical systems to the electromagnetic pulse (EMP) associated with the exoatmospheric detonation of a nuclear weapon. Along with this major objective, MSEP is tasked also with the aim to develop experimental and analytical evaluation techniques that are applicable to all systems' problems. These objectives are satisfied, since SEMCON provides an analytic method to examine various semiconductor devices used in Army systems and assists in making recommendations for hardening modifications.

When making EMP vulnerability assessments, it is often necessary to perform a circuit analysis on specific circuits driven by a voltage induced by EMP. This analysis often points out a large power value produced on various semiconductor devices that could cause the devices to fail if sufficient power were present. However, to know if a particular device fails and at what power level, a semiconductor device must be analyzed and a damage curve fitted to certain data. This curve gives a good indication as to the vulnerability of the device to particular thresholds of power. Therefore, the main purpose of computer code SEMCON is to provide the necessary information about semiconductor devices so that it is possible to make various EMP vulnerability assessments.

The semiconductor damage-data-reduction computer code, SEMCON, analyzes various semiconductor devices. The code was written for a Control Data Corporation (CDC) 6600 series computer system located at the Mobility Equipment Research and Development Center (MERDC), Fort Belvoir, VA. Written to run employing the FTN compiler, SEMCON is operational using the SCOPE 3.4.3 control language. To evaluate a semiconductor device, SEMCON is capable of giving the following information:

a. Determination of damage--the failure or nonfailure of a device

b. Calculations of power, energy, and impedance

c. Least-squares fits of

$p = at^{-1}$,

$p = bt^{-\frac{1}{2}}$,

$p = at^{-1} + bt^{-\frac{1}{2}}$

to either power versus failure time or power versus pulse width

d. Selection of the best least-squares fit to specified data

e. Log-log plots of least-squares fits in either the forward or reverse direction

f. Log-log plots of

TD versus Z--failure time versus impedance

TD versus VOC--failure time versus open-circuit voltage

TDOC versus VOC--pulse duration versus open-circuit voltage

TD versus IP--failure time versus peak current

in either the forward or reverse direction

g. Tabular listing of input data and all calculations

The subsequent sections detail the development and capabilities of SEMCON, along with the necessary information to utilize the code.

2. FAILURE DETERMINATION AND POWER, ENERGY, AND IMPEDANCE CALCULATIONS

To determine the damage on a particular pulse number, the specific values used in the calculations are (1) VZBP and VZAP, (2) VZBN and VZAN, and (3) GAINB and GAINA. The criteria used to determine failure are any one of the following three conditions:

a. .8*VZBP - VZAP > 0

b. .8*VZBN - VZAN > 0

c. .8*GAINB - GAINA > 0

If any one of these conditions is satisfied, then for that pulse number the device is said to fail.

Another of the features of SEMCON is the calculations of the power (P), energy (E), and impedance (Z). These computations are very straightforward and are found by

$$P = VP*TD,$$

$$E = P*TD,$$

$$Z = \frac{VP - VZBP}{IP} .$$

3. DERIVATION OF FITTING PARAMETERS

The main purpose of SEMCON is to fit various curves to specified data. They are fit by using the method of least squares to calculate the various fitting parameters. The plots of these curves, as well as the data, are scaled logarithmically, since there can be a wide range in the values of the data. Thus, it is necessary to calculate the least-squares fits in terms of logarithms, which introduces a nonlinear problem. Two methods are used to calculate the least-squares fits in SEMCON. One uses the minimizing conditions known as the normal equations, and the other uses a minimization technique to find the minimum of a function of two variables. In the following paragraphs, the two methods are explained fully along with a detailed derivation of the least-squares fitting parameters.

The first method used to find the least-squares fits involves the solution of the normal equations. This technique involves substituting the n data pairs into the fitting equation.

$$f(x) = a_1\phi_1(x) + a_2\phi_2(x) + \ldots + a_k\phi_k(x),$$

where $\phi_i(x)$ are known functions of x, and a_i are the k linear fitting parameters, thus obtaining n linear equations with k unknowns. The next step is to multiply each equation by its corresponding coefficient of the first unknown, which results in n new equations. Adding these equations gives the first normal equation. This process is repeated k times with respect to each of the unknown parameters, so that we end up with k equations in k unknowns (the fitting parameters). The resulting system of simultaneous linear equations, known as the normal equations, is then solved for the k fitting parameters.

In our particular case, we wish to use this method to fit

$$p = at^{-1},$$

$$p = bt^{-\frac{1}{2}}$$

to experimental data, where p is the power, t is the failure time, and a and b are the fitting parameters. Since plots are desired that are scaled logarithmically, we must find the parameters a and b by applying the least-squares technique to

$$\log p = \log at^{-1}, \tag{1}$$

$$\log p = \log bt^{-\frac{1}{2}}. \tag{2}$$

All logarithms are assumed to be to the base 10. By the elementary properties of logarithms, we clearly have a linear problem, since

$$\log p = \log a - \log t,$$

$$\log p = \log b - \tfrac{1}{2} \log t.$$

First, we consider $\log p = \log at^{-1}$ and suppose we have n data pairs (t_i, p_i) for $1 \leq i \leq n$. Substituting into equation (1), we get

$$\log p_1 = \log at_1^{-1},$$

$$\log p_2 = \log at_2^{-1},$$

$$\vdots$$

$$\log p_n = \log at_n^{-1},$$

and simplifying gives

$$\log p_1 = \log a - \log t_1,$$

$$\log p_2 = \log a - \log t_2,$$

$$\vdots$$

$$\log p_n = \log a - \log t_n.$$

Since this system is linear in terms of logarithms, multiplying by the coefficient of log a in each equation and adding gives

$$\sum_{i=1}^{n} \log p_i = \sum_{i=1}^{n} \log a - \sum_{i=1}^{n} \log t_i.$$

This is the only normal equation, since there is only one fitting parameter. Solving for log a, we obtain

$$\log a = \frac{\sum_{i=1}^{n} \log p_i + \sum_{i=1}^{n} \log t_i}{n},$$

which gives the solution for a as

$$a = 10^x ,$$

where

$$x = \frac{1}{n}\left(\sum_{i=1}^{n} \log p_i + \sum_{i=1}^{n} \log t_i\right).$$

Now, considering $\log p = \log bt^{-\frac{1}{2}}$ and proceeding as above, we get

$$\log p_1 = \log b - \tfrac{1}{2} \log t_1 ,$$

$$\log p_2 = \log b - \tfrac{1}{2} \log t_2 ,$$

$$\vdots$$

$$\log p_n = \log b - \tfrac{1}{2} \log t_n .$$

This system also is linear in terms of logarithms, so multiplying by the coefficient of log b in each equation and adding gives

$$\sum_{i=1}^{n} \log p_i = \sum_{i=1}^{n} \log b - \tfrac{1}{2} \sum_{i=1}^{n} \log t_i .$$

Again, this is the only normal equation, since there is only one fitting parameter. Solving for log b, we obtain

$$\log b = \frac{\sum_{i=1}^{n} \log p_i + \tfrac{1}{2} \sum_{i=1}^{n} \log t_i}{n} ,$$

which gives the solution for b as

$$b = 10^y ,$$

where

$$y = \frac{1}{n}\left(\sum_{i=1}^{n} \log p_i + \tfrac{1}{2} \sum_{i=1}^{n} \log t_i\right) .$$

The second method employed to calculate the least-squares fits involves finding a minimum of a function. Suppose we want to fit

$$f(x) = a_1\phi_1(x) + a_2\phi_2(x)$$

to n data points, where $\phi_1(x)$, $\phi_2(x)$ are known functions of x, and a_1, a_2 are the fitting parameters. Let $\bar{f}_i = \bar{f}(x_i)$ for $1 \le i \le n$ be the experimental data that we wish to fit. Then by the principle of least squares, we want to minimize

$$F(a_1, a_2) = \sum_{i=1}^{n} w(x_i)\left[\bar{f}_i - f(x_i)\right]^2,$$

where $w(x_i)$ is the weight function for each x_i. For our case, we choose

$$w(x_i) = 1 \text{ for } 1 \le i \le n.$$

Thus, we must find the minimum of

$$F(a_1, a_2) = \sum_{i=1}^{n} \left\{\bar{f}_i - \left[a_1\phi_1(x_i) + a_2\phi_2(x_i)\right]\right\}^2 .$$

To find the minimum, we proceed in the following manner:

a. Start with initial values $a_1^{(0)}$, $a_2^{(0)}$.

b. At the ith step, halve $a_1^{(i)}$, and try to step first in the positive and then in the negative x-direction, to see if either resulting value gives a minimum, i.e.,

$$F\left[a_1^{(i)} \pm \frac{a_1^{(i)}}{2^j}, a_2^{(i)}\right] < F\left[a_1^{(i)}, a_2^{(i)}\right] .$$

c. Halve $a_2^{(i)}$, and try to step first in the positive and then in the negative y-direction, to see if either resulting value gives a minimum, i.e.,

$$F\left[a_1^{(i)},\ a_2^{(i)} \pm \frac{a_2^{(i)}}{2^j}\right] < F\left[a_1^{(i)},\ a_2^{(i)}\right].$$

d. If neither (b) nor (c) gives a minimum halve $a_1^{(i)}$ and $a_2^{(i)}$ again, and repeat (b) and (c), i.e., j = 2.

e. If a minimum results from either (b) or (c), then let

$$a_1^{(i+1)} = a_1^{(i)} \pm \frac{a_1^{(i)}}{2^j},\ a_2^{(i+1)} = a_2^{(i)},\ \text{if only (b) holds,}$$

$$a_2^{(i+1)} = a_2^{(i)} \pm \frac{a_2^{(i)}}{2^j},\ a_1^{(i+1)} = a_1^{(i)},\ \text{if only (c) holds,}$$

$$a_1^{(i+1)} = a_1^{(i)} \pm \frac{a_1^{(i)}}{2^j},\ a_2^{(i+1)} = a_2^{(i)} \pm \frac{a_2^{(i)}}{2^j},\ \text{if (b) and (c) hold,}$$

and check

$$\left| F\left[a_1^{(i+1)},\ a_2^{(i+1)}\right] - F\left[a_1^{(i)},\ a_2^{(i)}\right] \right| < \varepsilon, \tag{3}$$

(3)

where ε is a chosen convergence tolerance. If equation (3) holds, then

$$a_1 + a_1^{(i+1)},\ a_2 = a_2^{(i+1)}$$

are the fitting parameters. If equation (3) does not hold, the process is repeated.

This technique is very simple and always leads to a minimum although it may be only a local minimum. If a local minimum is reached which is not close to the true minimum, then it seems reasonable to assume that the least-squares fit will be poor. Thus, when the fit is bad, it could probably be attributed to this distant local minimum, although there are other occurrences that could cause a bad fit. The

only solution to this problem is to try the minimization technique again with different initial values. A repetition of this process leads to the true minimum of the function $F(a_1, a_2)$. The above technique was limited to two fitting parameters, but it is an easy matter to extend this method to k parameters.

For our purpose, we wish to use this method to fit

$$p = at^{-1} + bt^{-\frac{1}{2}} \tag{4}$$

to experimental data $(t_i, \overline{p}_i)$ for $1 \leq i \leq n$, where p is the power, t is the failure time, n is the number of data points, and a and b are the fitting parameters. This poses a nonlinear problem, since log $(at^{-1} + bt^{-\frac{1}{2}})$ cannot be linearized as was log (at^{-1}) and log $(bt^{-\frac{1}{2}})$. This problem is easily overcome by using the minimization technique described above. Let

$$P(t; a,b) = \log (at^{-1} + bt^{-\frac{1}{2}}),$$

and we want to minimize

$$S(a,b) = \sum_{i=1}^{n} w(t_i) \left[\log \overline{p}_i - P\left(t_i; a,b\right)\right]^2 ,$$

where $w(t_i)$ is the weight function for each t_i. Since we choose

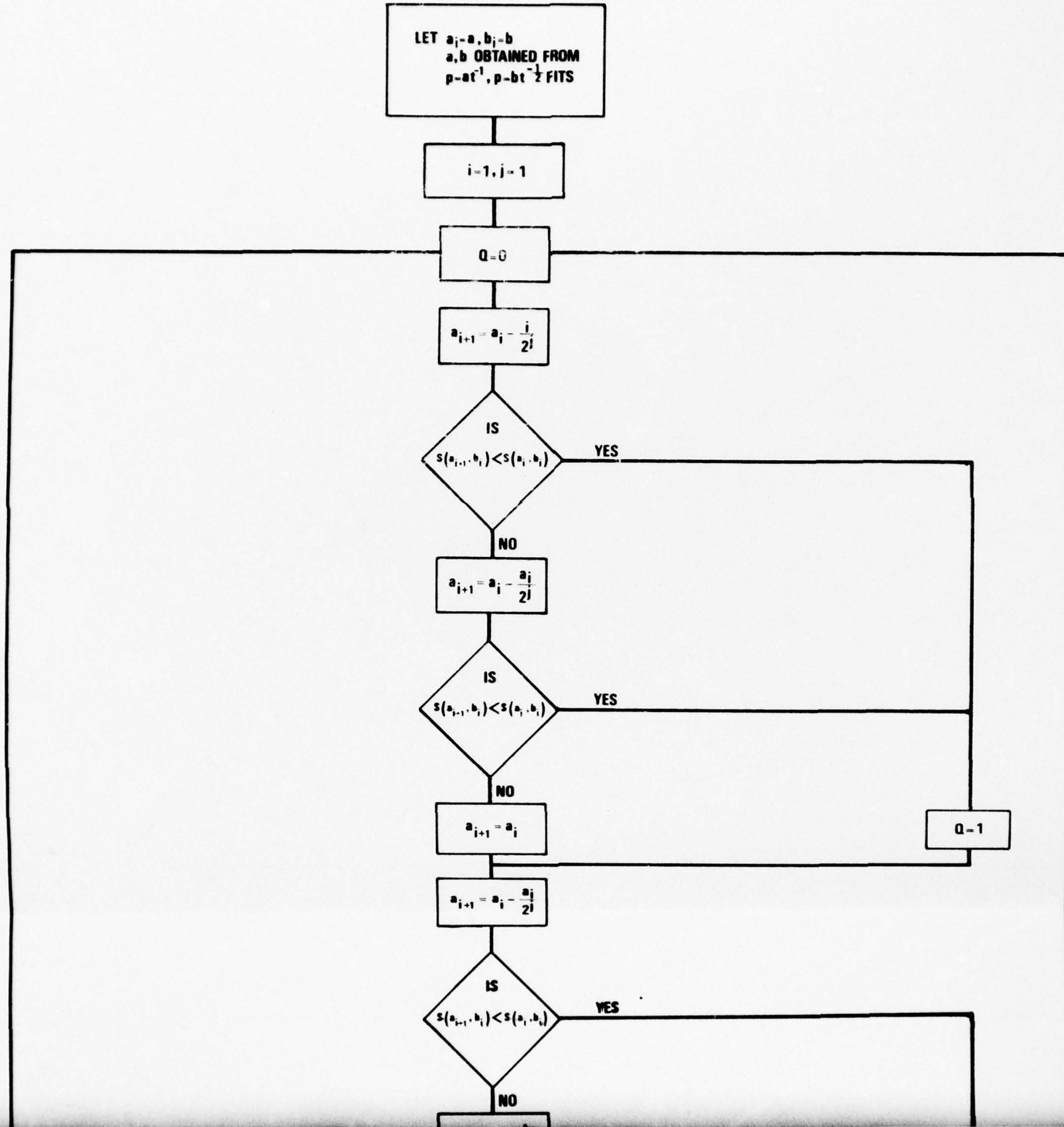
$$w(t_i) = 1 \quad \text{for } i = 1, 2, \ldots n,$$

we must minimize

$$S(a,b) = \sum_{i=1}^{n} \left[\log \overline{p}_i - \log\left(at_i^{-1} + bt_i^{-\frac{1}{2}}\right)\right]^2 .$$

The minimization for S(a,b) is identical to the minimization technique given above. A flow chart for finding the minimum of S(a,b) and thus the fitting parameters a and b is given in figure 1.

Although the techniques outlined above are simple and straightforward, caution should be taken when interpreting the least-squares fits. First, the fits are only as good as the data. Poorly taken and recorded data result in meaningless fits. Probably the major fault with least squares is that a single very wrong measurement greatly distorts the results, because in the squaring process, large



LET $a_i = a, b_i = b$
a,b OBTAINED FROM
$p = at^{-1}, p = bt^{-\frac{1}{2}}$ FITS
$i = 1, j = 1$
Q = 0
$a_{i+1} = a_i - \frac{i}{2^j}$
IS
$s(a_{i+1}, b_i) < s(a_i, b_i)$
YES
NO
$a_{i+1} = a_i - \frac{a_j}{2^j}$
IS
$s(a_{i+1}, b_i) < s(a_i, b_i)$
YES
NO
$a_{i+1} = a_i$
Q = 1
$a_{i+1} = a_i - \frac{a_j}{2^j}$
IS
$s(a_{i+1}, b_i) < s(a_i, b_i)$
YES
NO

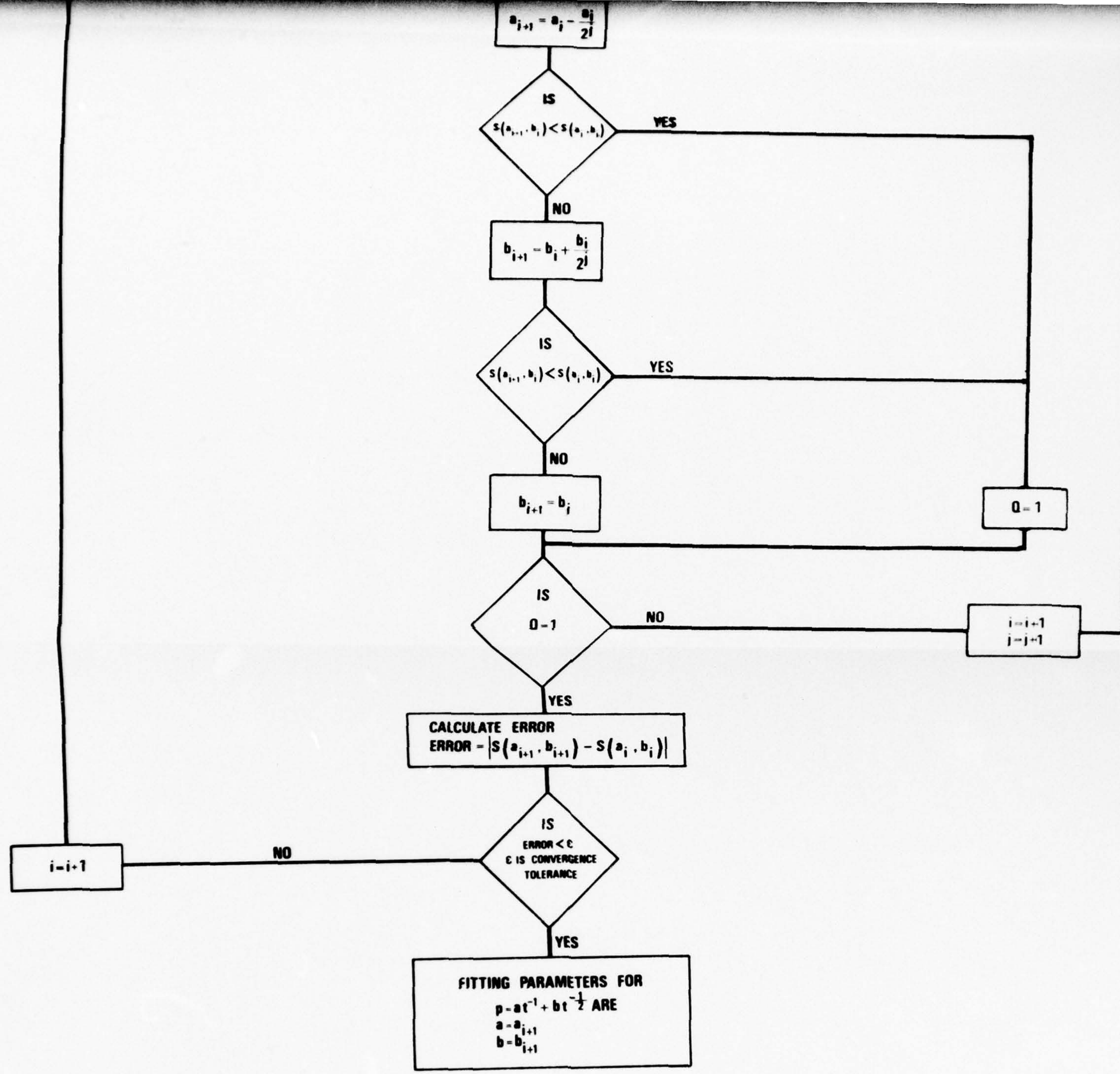


Figure 1. Flow chart for minimizing S(a,b).

residuals are dominant--one gross error 10 times larger than most of the others has the same effect in the sum of the squares as have 100 of the others.[1] Second, a considerable amount of mathematical and statistical sophistication can be employed to give the fits much more reliability when the proper data are involved. Several statistical techniques can be applied to these least-squares fits that would enhance their assurance. One is a statistical test of hypothesis concerning the confidence in the fitting parameters a, b in equations (1),(2), and (4). The other would be to test the goodness of fit by using the χ^2 statistical test. These two techniques can be utilized to make SEMCON's least-squares fits more reliable.

4. GAUSS CRITERION OF GOODNESS OF FIT

One of the main questions pertaining to least-squares fits concerns the goodness of fit of the curve to the data. This problem can be dealt with when using the least-squares technique, and probably the most widely used method is the χ^2 goodness of fit statistical test. Although the χ^2 test has not been utilized in SEMCON, a test to determine which of the curves

$$p = at^{-1}$$

$$p = bt^{-\frac{1}{2}}$$

$$p = at^{-1} + bt^{-\frac{1}{2}}$$

best fits the data is applied. This test, known as the Gauss criterion of goodness of fit, is now explained. Let $\bar{p}_i$ be an experimental value, p_i a value computed from a least-squares fit, n the number of data points, and m the number of fitting parameters in the relation. Then we define

$$\Omega = \frac{\sum_{i=1}^{n}\left(\bar{p}_i - p_i\right)^2}{n - m},$$

and the Gauss criterion of goodness of fit states that the best fit is the one that minimizes Ω. Since the plots of these fits are scaled logarithmically, we calculate

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[1] *R. W. Hamming, Numerical Methods for Scientists and Engineers, 2nd edition, McGraw-Hill Book Co., Inc., New York (1973).*

$$\Omega = \frac{\sum_{i=1}^{n} \left(\log \bar{p}_i - \log p_i\right)^2}{n - m}$$

and find the curve that minimizes Ω. Values of Ω are printed in the output of SEMCON, as well as the curve that best fits the data. This can be seen in appendices A and B.

5. PLOTTING INFORMATION

There are several ways to obtain the plots generated by SEMCON. Through MERDC, SEMCON has the capability to use a Cal Comp model 835 cathode ray tube (CRT) plotting system. This system takes plotting information from a magnetic tape and converts the data to be plotted to incremental plotter commands, which produce discrete, electron-beam deflections (relative to the x and y axes) and intensity variations on the face of a CRT. The CRT display is transmitted through a camera lens system and recorded on 35-mm microfilm. The exposed film is then processed, and the plots are recorded on a magnetic tape at the MERDC computer center. A call to the MERDC computer center is necessary to initiate the hard-copy processing of the plots from the magnetic tape.

In addition to the CRT plotting system, SEMCON has the ability to use a Mohawk Data Sciences (MDS) model 2400 remote batch terminal accompanied with a Houston Instruments COMPLOT plotting system. This system, located at the Harry Diamond Laboratories (HDL) Woodbridge Research Facility (WRF), enables all plots and output information to be received on site.

Each of the methods to obtain plots from SEMCON has different plotting software. Examples of this software are contained in appendices A and B.

6. OPTIONS OF SEMCON

The output of SEMCON can be varied substantially, so an analysis of the possible options for outputing various information is essential. The following is a description of the options available.

a. Tabular data options

(1) Listing of tabular data only--no plots are given.

(2) Listings of tabular data and plots are given.

(3) Plots are given, but the tabular listing is suppressed.

b. Plotting selections

(1) Available items versus item plots are

(a) TD versus Z--failure time versus impedance

(b) TD versus VOC--failure time versus open-circuit voltage

(c) TDOC versus VOC--pulse duration versus open-circuit voltage

(d) TD versus IP--failure time versus peak current.

(2) Plots in the reverse direction only

(3) Plots in the forward direction only

(4) Plots in both forward and reverse directions

(5) No item versus item plots

(6) Reverse direction item versus item plots only

(7) Forward direction item versus item plots only

(8) Forward and reverse direction item versus item plots only

(9) Forward and reverse direction item versus item plots and least-squares fits

(10) Plots may be received on the MDS remote batch terminal or at MERDC.

(11) Plotting software may be either the regular Cal Comp plotting software or the software available through the MDS remote batch terminal.

c. Input data--The regular input data may be entered or a simpler form of input data that requires only pulse width versus power entires.

d. Least-squares fits--Three curves may be fitted to either failure time (TD) versus power (P) or pulse width versus power.

(1) Fit to $p = at^{-1}$ and $p = bt^{-\frac{1}{2}}$ only.

(2) Fit to $p = at^{-1} + bt^{-\frac{1}{2}}$ only.

(3) Fit to all three equations.

7. DESCRIPTION OF SEMCON AND ITS SUBROUTINES

The SEMCON code consists of a main program and 19 subroutines. The documentation of SEMCON is detailed by the following analysis of the main program and its subroutines. A listing of SEMCON can be found in appendix C.

SEMCON reads in the data and writes the tabular output seen in appendix A. It also makes the power, energy, and impedance calculations.

FAILUR calculates the failure or nonfailure of each pulse number.

FRFAIL separates the data with respect to failure in the reverse or forward directions.

DIRECT sets up the variables T and PP, which are used in the calculations of the three least-squares fits, with respect to either the forward or reverse direction. Also, DIRECT chooses which least-squares fit will be calculated.

WRITE outputs the various fitting parameters for the chosen least-squares fit. Also, some other useful information is written, such as the curve that best fits the data and the minimum of the function S(a,b) (sect. 4).

PLOTT contains all the plot titles and axes information and labels. This subroutine initiates the plotting of all curves by calling PWRITE.

ALSQAR calculates the fitting parameter for $p = at^{-1}$.

BLSQAR calculates the fitting parameter for $p = bt^{-\frac{1}{2}}$.

ABLSQAR calculates the fitting parameters for $p = at^{-1} + bt^{-\frac{1}{2}}$.

PWRITE performs the plotting using the Cal Comp model 835 CRT plotting system by calling the WRF library routines in TALPLOT. The subroutines SELPLOT, TALGRAF, and TALDATA of TALPLOT are referenced in PWRITE only.

SELPLOT selects the beam intensity of the Cal Comp model 835 microfilm plotter and also enables the user to choose if he wants the plots sent to the MDS system at WRF.

TALGRAF sets up the plot axes and labels and specifies the number of sets of data to be plotted on one graph.

TALDATA plots a set of (x,y) data pairs.

SORT sorts the data in array T of subroutine DIRECT in increasing order so that the plotting is done correctly.

GOODFIT calculates the sum of the squares of the difference between the experimental value and the corresponding value computed from a least-squares fit for each least-squares fit. This sum is used in the Gauss criterion of goodness of fit.

GAUSS Determines the best fit for the data by the Gauss criterion and outputs the correct fit.

SAB calculates the functional values of S(a,b) (sect. 4).

OWNDAT enables the user to enter only data for pulse width versus power input. It outputs these data by calling COLMNS and makes the appropriate calls to the other routines to calculate the least-squares fits and make the desired plots.

COLMNS outputs the data for pulse width versus power in increasing columns.

CHANGE changes the abscissa and ordinate titles to correspond with the use of data for pulse width versus power. It also enters those data into the plotting software.

8. DATA INPUT PREPARATION

Input cards are prepared for SEMCON in the following manner.

Card	Columns	Variable name	Format	Comment
Card set 1: Plot and parameter card				
1	10	IND	I1	IND = 1, plot in reverse direction only IND = 2, plot in forward direction only IND = 3, plot in both directions

Card	Columns	Variable name	Format	Comment
1	20	FLAG	I1	FLAG = 1, least-squares fit to $p = at^{-1}$ and $p = bt^{-\frac{1}{2}}$ FLAG = 2, least-squares fit to $p = at^{-1} + bt^{-\frac{1}{2}}$ FLAG = 3, least-squares fit to all three equations
	30	IPRAM	I1	IPRAM = 0, no item versus item plots IPRAM = 1, reverse direction item versus item plots only IPRAM = 2, forward direction item versus item plots only IPRAM = 3, forward and reverse direction item versus item plots only IPRAM = 4, forward and reverse direction item versus item plots and all curves as specified by IND and FLAG
	40	ISTOP	I1	ISTOP = 1, tabular output only ISTOP = 2, tabular output and all output designated by IND, FLAG, and IPRAM ISTOP = 3, no tabular output, but all plots as indicated
	49-50	IPLOT	I2	IPLOT = 0, plots come out on MDS system IPLOT = K, where $1 < K < 36$ indicates beam intensity of Cal Comp plotter; a good value is IPLOT = 18; plots come out at MERDC NOTE: ITYPE must be equal to 0.
	60	ISEM	II	ISEM = 0, enter all input data in card sets 3 and 4 ISEM = 1, enter only pulse width versus power data on card set 5

Card	Columns	Variable name	Format	Comment
1	70	ITYPE	II	ITYPE = 0, regular Cal Comp plotting software is used ITYPE = 1, plotting software available on MDS remote batch terminal is used

Card set 2: Title card

Card	Columns	Variable name	Format	Comment
2	1-3	NUMB	I3	If ISEM = 0 on card 1, NUMB is total number of devices If ISEM = 1 on card 1, NUMB is number of pulse width versus power points
	4-11	DEV	A8	Device name
	12-31	DEVTYP1,DEVTYP2	2A10	Device type
	32-40	JUNC	A9	Junction of device
	41-60	MAN1, MAN2	2A10	Manufacturer of device
	61-70	TECH	A10	Technician
	71-80	DATEE	A10	Date
				NOTE: If ISEM = 1 on card 1, skip to card set 5.

Card set 3: Pulse card

Card	Columns	Variable name	Format	Comment
3	1-2	NPULS	I2	Total number of pulses for particular device number
	3-80	-	-	Any comments or notations may be placed in these columns
				NOTE: Card set 3 is repeated as many times as indicated on card set 2 for variable NUMB, and thus card set 4 is repeated this same number of times.

Card	Columns	Variable name	Format	Comment
Card set 4: Parameter value cards				
4	1-3	NDEV	I3	Device number; total number of repetitions of this card must not exceed 600
	4-5	PULSE	I2	Pulse number; not to exceed 99
	6-15	TDOC	E10.3	Pulse duration
	16-25	VOC	F10.3	Open-circuit voltage
	26-35	VP	F10.3	Peak voltage
	36-45	IP	F10.3	Peak current
	46-55	TD	E10.3	Failure time (TD $\neq$ 0)
	56-65	VZBP	F10.3	Voltage before forward breakdown voltage
5	1-10	VZAP	F10.3	Voltage after forward breakdown voltage
	11-20	VZBN	F10.3	Zener voltage before reverse breakdown voltage
	21-30	VZAN	F10.3	Zener voltage after reverse breakdown voltage
	31-40	GAINB	E10.3	Current gain before device was pulsed
	41-50	GAINA	E10.3	Current gain after device was pulsed
	51-52	PIN	A2	Polarity of applied pulse: A+ = forward direction C+ = reverse direction
	53-71	REMAR1,REMAR2	A10,A9	Remarks
				NOTE: Card set 4 represents data for one pulse and is repeated as many times as indicated on card set 3 for variable NPULS.
				If ISEM = 0 on Card 1, data input is complete

Card	Columns	Variable name	Format	Comment
Card set 5: Pulse width and power cards				
6	1-20	IDENT1,IDENT2	2A10	Identification of data
	21-30	-	-	Blank
	31-40	XLAB	A10	Abscissa label
	41-50	-	-	Blank
	51-60	YLAB	A10	Ordinate label
7	1-10	T	E10.3	Pulse width
	11-20	PP	E10.3	Power
				NOTE: Data for pulse width versus power must be arranged in increasing order with respect to pulse width.
				Card 7 is repeated according to value NUMB appearing on Card 2

A sample listing of the input cards when ISEM = 0 on card set 1 is given in appendix D. Also, a sample listing of the input cards when ISEM = 1 on card set 1 is contained in appendix E.

9. CONTROL CARDS FOR RUNNING SEMCON

The SEMCON code is operational using the SCOPE 3.4.3 control language on the CDC 6600 computer at MERDC. Since several different plotting packages can be used, three distinct control card sets are required for the various options available. The following details the operation of the code.

If IPLOT = K where $1 \leq K \leq 36$ on card set 1 (plots come out at MERDC using the Cal Comp plotting software), then the control cards for running SEMCON are as follows:

```
EM___(MT1, T300)

TASK(TNEM_____,PW_____,TRTS)  [user's name]

REQUEST, TAPE50, HI, VSN=____,RING.
```

NOTE: VSN=____is the number of the blank tape at MERDC.

```
ATTACH,AGO,BINSEMCON,ID=EM71606.

ATTACH,F1,TALWYATT,ID=EM71602,MR=1.

LIBRARY(F1)

MAP(PART)

LDSET(PRESET=NGINF)

AGO.

TALPLOT(,TAPE1)

EXIT.

7/8/9

[Data]

0/6/7/8/9
```

If *IPLOT = 0* and *ITYPE = 0 on card set 1 (plots come out on the* MDS system using the Cal Comp plotting software), then the control cards for running SEMCON are as follows:

```
EM___(T300)

TASK(TNEM_____,PW_____,TRTS) [user's name]

ATTACH,AGO,BINSEMCON,ID=EM71606.

ATTACH,F1,TALWYATT,ID=EM71602,MR=1.

ATTACH,LIBA,ANAPAC,ID=EM71605,MR=1.

LIBRARY(F1,LIBA)

MAP(PART)

LDSET(PRESET=NGINF)

AGO.

TALPLOT(,TAPE1)
```

```
EXIT.

7/8/9

[Data]

0/6/7/8/9
```

If IPLOT = 0 and ITYPE = 1 on card set 1 (plots come out on the MDS system using the ANAPAC plotting software), then the control cards for running SEMCON are as follows:

```
EM___(T300)

TASK(TNEM_____,PW_____,TRTS) [user's name]

ATTACH,AGO,BINSEMCON,ID=EM71606.

ATTACH,LIBA,ANAPAC,ID=EM71605,MR=1.

LIBRARY(LIBA)

MAP(PART)

LDSET(PRESET=NGINF)

AGO.

EXIT.

7/8/9

[Data]

0/6/7/8/9
```

10. CONCLUSIONS

The SEMCON code has provided the means to analyze various semiconductor devices and, hence, assist in making EMP vulnerability assessments. The code has accomplished this objective by utilizing very straightforward techniques to calculate the least-squares fits for damage curves of semiconductor devices. For EMP efforts, the fits generated by SEMCON are considered to be reliable when good, accurate data are used. Also, the code has proven to be quite effective in tabulating and reducing numerous amounts of data. Thus, SEMCON is considered to be a useful code in semiconductor damage analysis and is written in such a way as to make it readily adaptable to numerous computer systems.

ABBREVIATIONS

E	Energy
FAIL	Failure
GAINA	Current gain after device was pulsed
GAINB	Current gain before device was pulsed
IP	Peak current
NDEV	Device number
P	Power
PIN	Polarity of applied pulse (i.e., reverse or forward direction)
PULSE	Pulse number
TD	Failure time
TDOC	Pulse duration
VOC	Open-circuit voltage
VP	Peak voltage
VZAN	Zener voltage after reverse breakdown voltage
VZAP	Voltage after forward breakdown voltage
VZBN	Zener voltage before reverse breakdown voltage
VZBP	Voltage before forward breakdown voltage
Z	Impedance

APPENDIX A.--SAMPLE PRODUCTION RUN OF SEMCON

This appendix contains examples of plots available through SEMCON and the computer center at the Mobility Equipment Research and Development Center, Fort Belvoir, VA.

SEMI-CONDUCTOR DAMAGE PROGRAM - VERSION OF JUNE,1975 06/09/76 09.41.28.

DEVICE: IN3600 DEVICE TYPE: DIODE JUNCTION: C-A
MANUFACTURER: FAIRCHILD TECHNICIAN: R.PARSONS DATE: 7-23-73

NO. PT	TDDC	VDC	VP	IP	TD	POWER	ENERGY	IMPEDANCE	VZB+	VZA+	VZB-	VZA-	GAINB	GAINA	PIN	FAIL	REMARKS
1- 1	.10E-04	100.0	100.0	0.0	.10E-04	0.	0.	0.	1.0	1.0	160.0	160.0	0.00	0.0	C+	NO	
1- 2	.10E-04	110.0	105.0	.2	.10E-04	.16E+02	.16E-03	.69E+03	1.0	1.0	160.0	160.0	0.00	0.0	C+	NO	
1- 3	.10E-04	120.0	115.0	.6	.22E-05	.69E+02	.15E-03	.19E+03	1.0	0.0	160.0	0.0	0.00	0.0	C+	YES	
2- 1	.10E-04	60.0	60.0	0.0	.10E-04	0.	0.	0.	.3	.3	92.0	92.0	0.00	0.0	C+	NO	
2- 2	.10E-04	70.0	70.0	0.0	.10E-04	0.	0.	0.	.3	.3	92.0	92.0	0.00	0.0	C+	NO	
2- 3	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	92.0	92.0	0.00	0.0	C+	NO	
2- 4	.10E-04	90.0	90.0	0.0	.10E-04	0.	0.	0.	.3	.3	92.0	92.0	0.00	0.0	C+	NO	
2- 5	.10E-04	100.0	80.0	1.3	.20E-05	.10E+03	.21E-03	.61E+02	.3	.3	92.0	92.0	0.00	0.0	C+	NO	BRKDWN NO VZ
2- 6	.10E-04	110.0	90.0	2.2	.80E-06	.20E+03	.16E-03	.41E+02	.3	.3	92.0	4.0	0.00	0.0	C+	YES	
3- 1	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	90.0	90.0	0.00	0.0	C+	NO	
3- 2	.10E-04	90.0	90.0	0.0	.10E-04	0.	0.	0.	.3	.3	90.0	90.0	0.00	0.0	C+	NO	
3- 3	.10E-04	100.0	95.0	.7	.30E-05	.67E+02	.20E-03	.14E+03	.3	0.0	90.0	0.0	0.00	0.0	C+	YES	
4- 1	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	98.0	98.0	0.00	0.0	C+	NO	
4- 2	.10E-04	90.0	90.0	0.0	.10E-04	0.	0.	0.	.3	.3	98.0	98.0	0.00	0.0	C+	NO	
4- 3	.10E-04	100.0	100.0	0.0	.10E-04	0.	0.	0.	.3	.3	98.0	98.0	0.00	0.0	C+	NO	
4- 4	.10E-04	110.0	105.0	1.0	.19E-05	.11E+03	.20E-03	.10E+03	.3	0.0	98.0	0.0	0.00	0.0	C+	YES	
5- 1	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	86.0	86.0	0.00	0.0	C+	NO	
5- 2	.10E-04	90.0	85.0	.6	.12E-05	.51E+02	.61E-04	.14E+03	.3	.3	86.0	83.0	0.00	0.0	C+	NO	BRKDWN DEVICE NO
5- 3	.10E-04	100.0	90.0	1.8	.12E-05	.16E+03	.19E-03	.50E+02	.3	.3	86.0	12.0	0.00	0.0	C+	YES	
6- 1	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	86.0	86.0	0.00	0.0	C+	NO	
6- 2	.10E-04	90.0	90.0	0.0	.10E-04	0.	0.	0.	.3	.3	86.0	86.0	0.00	0.0	C+	NO	
6- 3	.10E-04	100.0	90.0	1.0	.12E-05	.90E+02	.11E-03	.90E+02	.3	0.0	86.0	0.0	0.00	0.0	C+	YES	
7- 1	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	86.0	86.0	0.00	0.0	C+	NO	
7- 2	.10E-04	90.0	90.0	0.0	.10E-04	0.	0.	0.	.3	.3	86.0	86.0	0.00	0.0	C+	NO	
7- 3	.10E-04	100.0	95.0	.4	.27E-05	.38E+02	.10E-03	.24E+03	.3	.3	86.0	86.0	0.00	0.0	C+	NO	
7- 4	.10E-04	100.0	90.0	1.2	.80E-06	.11E+03	.86E-04	.75E+02	.3	.3	86.0	17.0	0.00	0.0	C+	YES	
8- 1	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	88.0	88.0	0.00	0.0	C+	NO	
8- 2	.10E-04	90.0	90.0	0.0	.10E-04	0.	0.	0.	.3	.3	88.0	88.0	0.00	0.0	C+	NO	
8- 3	.10E-04	100.0	100.0	0.0	.10E-04	0.	0.	0.	.3	.3	88.0	88.0	0.00	0.0	C+	NO	
8- 4	.10E-04	110.0	110.0	0.0	.10E-04	0.	0.	0.	.3	.3	88.0	88.0	0.00	0.0		NO	
8- 5	.10E-04	118.0	105.0	1.2	.10E-05	.13E+03	.13E-03	.87E+02	.3	.3	88.0	10.0	0.00	0.0	C+	YES	
9- 1	.50E-05	80.0	80.0	0.0	.50E-05	0.	0.	0.	.3	.3	93.0	93.0	0.00	0.0	C+	NO	
9- 2	.50E-05	90.0	90.0	0.0	.50E-05	0.	0.	0.	.3	.3	93.0	93.0	0.00	0.0	C+	NO	
9- 3	.50E-05	100.0	95.0	.6	.28E-05	.57E+02	.16E-03	.16E+03	.3	.3	93.0	93.0	0.00	0.0	C+	NO	
9- 4	.50E-05	112.0	100.0	.9	.90E-06	.90E+02	.81E-04	.11E+03	.3	.2	93.0	0.0	0.00	0.0	C+	YES	
10- 1	.50E-05	80.0	80.0	0.0	.50E-05	0.	0.	0.	.3	.3	93.0	93.0	0.00	0.0	C+	NO	
10- 2	.50E-05	90.0	90.0	0.0	.50E-05	0.	0.	0.	.3	.3	93.0	93.0	0.00	0.0	C+	NO	
10- 3	.50E-05	100.0	97.0	.2	.11E-05	.19E+02	.21E-04	.48E+03	.3	.3	93.0	93.0	0.00	0.0	C+	NO	
10- 4	.50E-05	110.0	103.0	.9	.18E-05	.93E+02	.17E-03	.11E+03	.3	.3	93.0	8.0	0.00	0.0	C+	YES	

```
REVERSE FAILURE CURVES AND DATA FOR DEVICE IN3600

      FITTING PARAMETER FOR P=A*T**(-1) IS:  A=  1.40305738E-04                  OMEGA=  2.14182431E-02

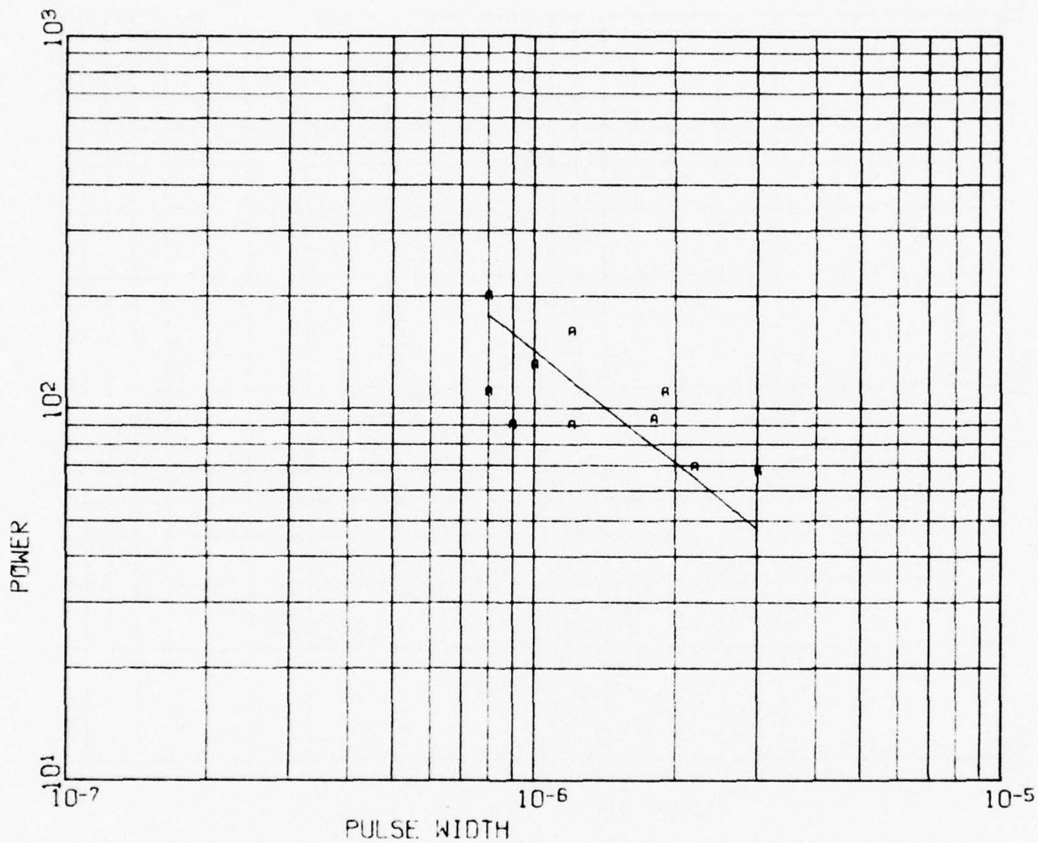
      FITTING PARAMETER FOR P=B*T**(-.5) IS:  B=  1.21187459E-01                 OMEGA=  1.19645338E-02

      FITTING PARAMETERS FOR P=A*T**(-1)+B*T**(-.5) ARE:  A=  3.35628819E-05     OMEGA=  1.40030432E-02
                                                          B=  9.28177482E-02

                    A AND B FOUND IN  24 ITERATIONS         MINIMUM OF S(A,B)=  1.12024345E-01

   GAUSS CRITERION OF GOODNESS OF FIT
      THE EQUATION WHICH BEST FITS THIS DATA IS:

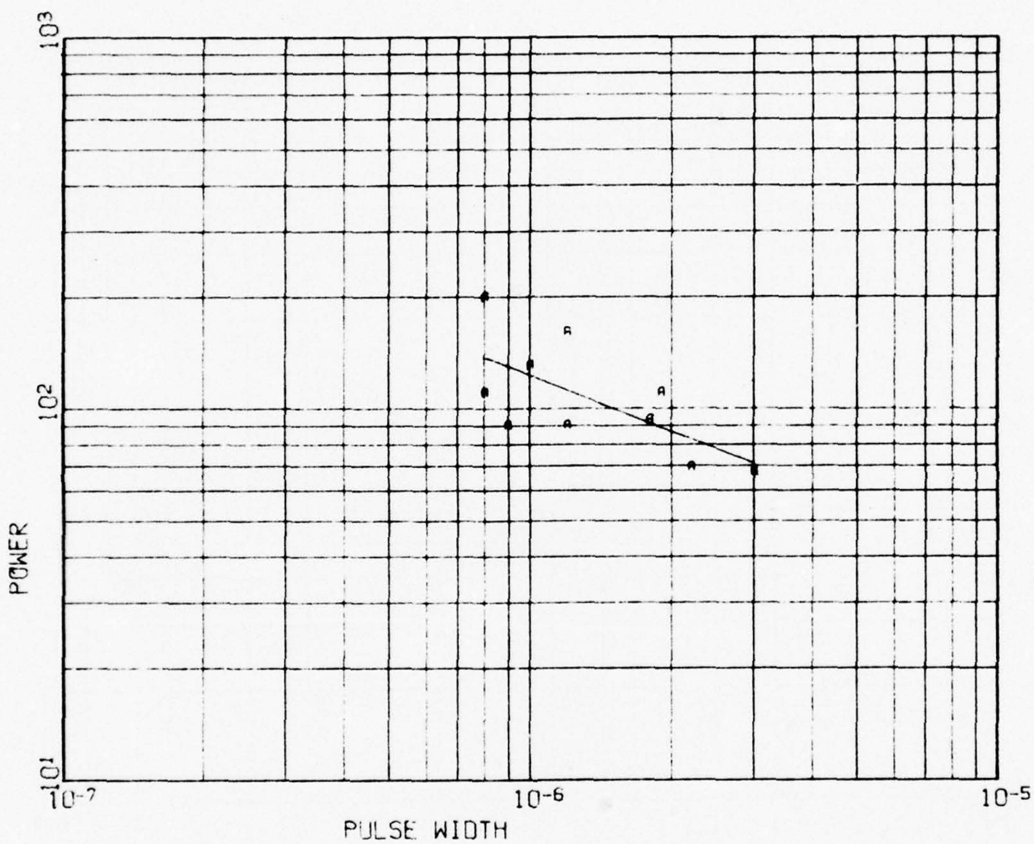
                    P=B*T**(-.5)
```



DEVICE: IN3600 REVERSE FAILURE

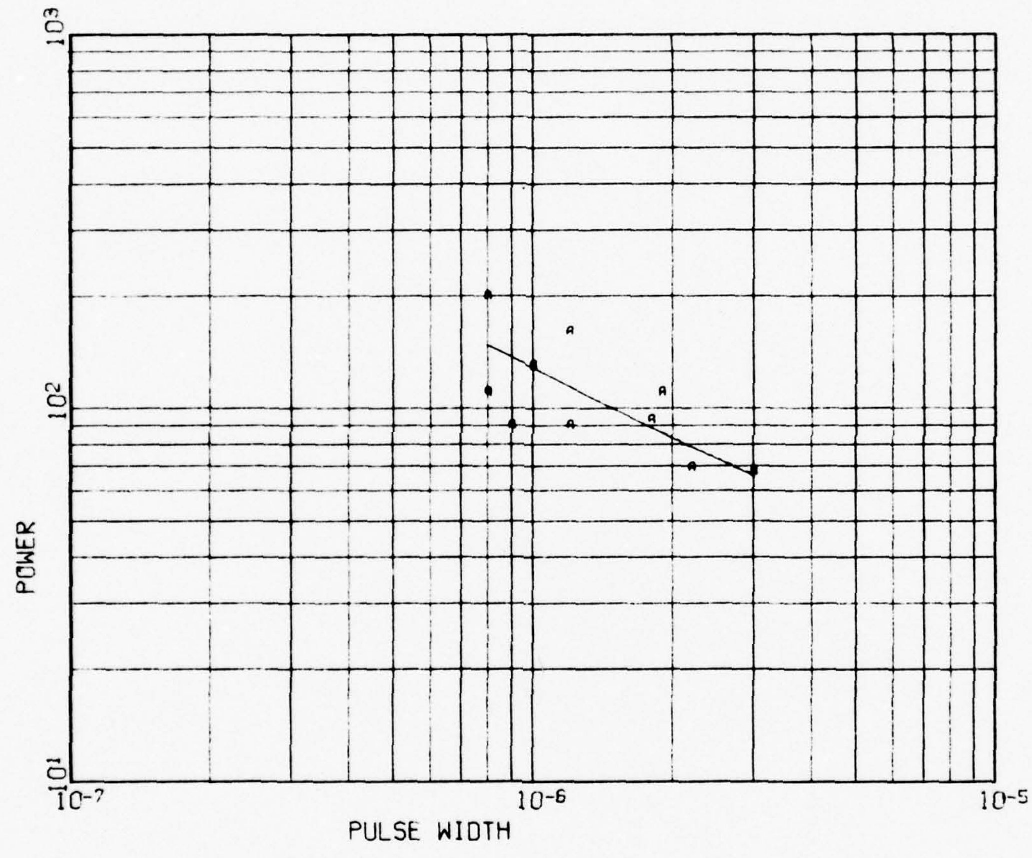
FIT TO P=A*T**(-1)

APPENDIX A



DEVICE: IN3600 REVERSE FAILURE

FIT TO P=B*T**(-.5)



DEVICE: IN3600 REVERSE FAILURE

FIT TO P=A*T**(-1)+B*T**(-.5)

APPENDIX B.--SAMPLE PRODUCTION RUN OF SEMCON

This appendix contains examples of plots available through SEMCON and the Mohawk Data Sciences computing system.

```
SEMI-CONDUCTOR DAMAGE PROGRAM - VERSION OF JUNE,1975                                06/10/76      11.58.41.

  DEVICE: IN3600      DEVICE TYPE: DIODE                        JUNCTION: C-A
  MANUFACTURER: FAIRCHILD                  TECHNICIAN: R.PARSONS    DATE: 7-23-73

  IDENTIFICATION: REVERSE FAILURE

     PULSE WDTH      POWER              PULSE WDTH      POWER              PULSE WDTH      POWER
     --------------------------         --------------------------         --------------------------
      8.000E-07      1.100E+02           1.200E-06      9.000E+01           1.900E-06      1.100E+02
      8.000E-07      2.000E+02           1.200E-06      1.600E+02           2.200E-06      6.900E+01
      9.000E-07      9.000E+01           1.800E-06      9.300E+01           3.000E-06      6.700E+01
      1.000E-06      1.300E+02


REVERSE FAILURE CURVES AND DATA FOR DEVICE IN3600

      FITTING PARAMETER FOR P=A*T**(-1) IS:  A=  1.41779212E-04                     OMEGA=  2.16628588E-02

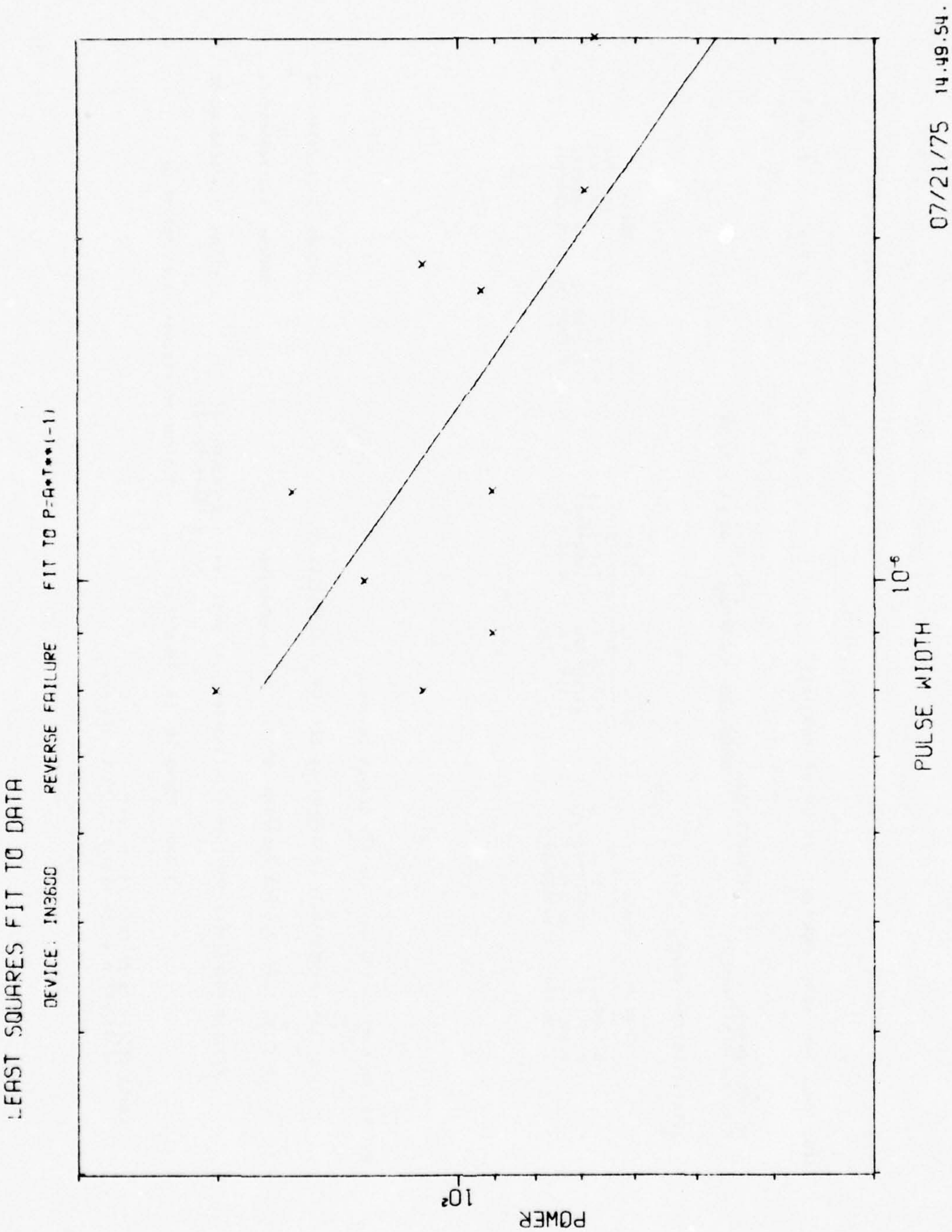
      FITTING PARAMETER FOR P=B*T**(-.5) IS:  B=  1.22460156E-01                    OMEGA=  1.21928344E-02

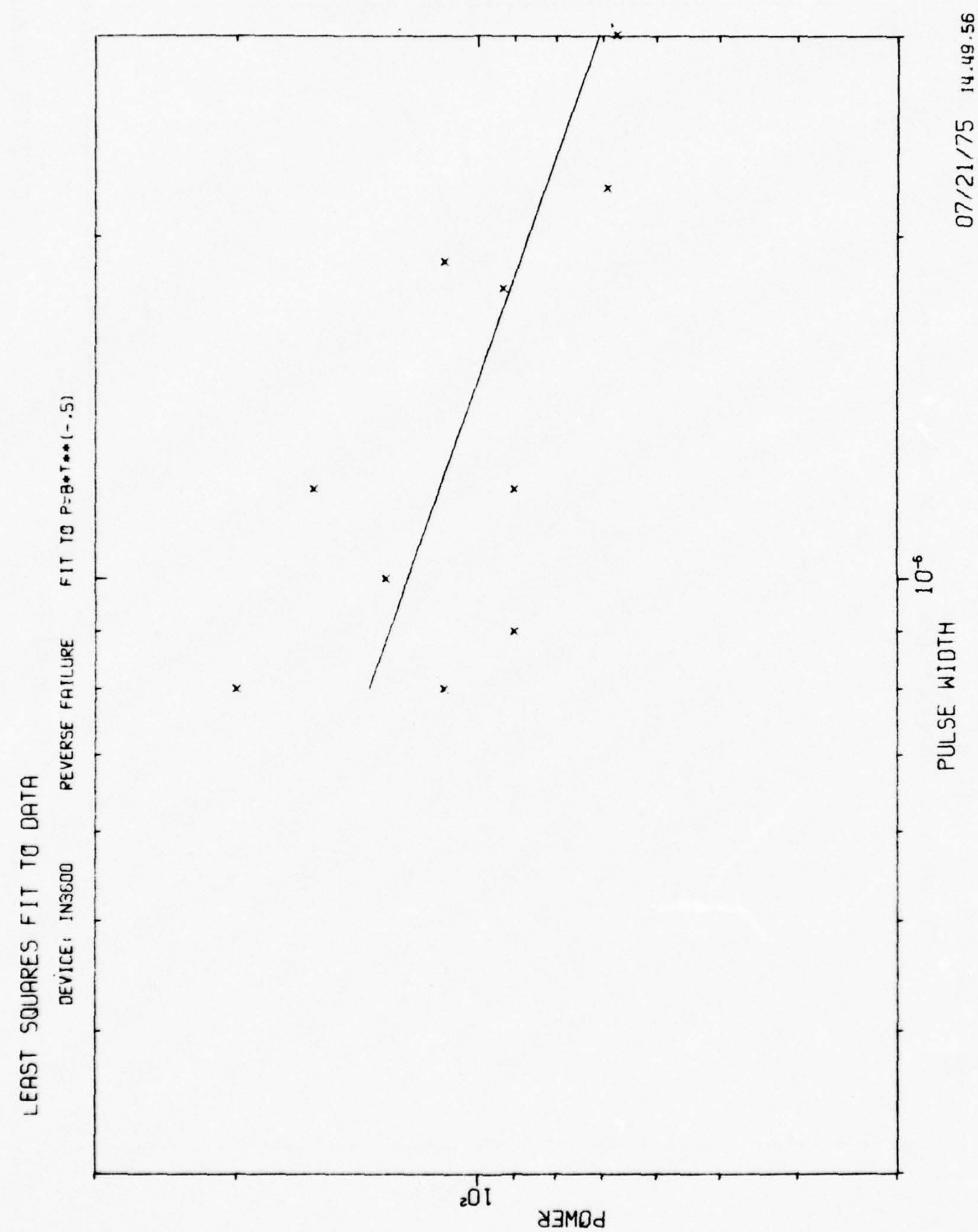
      FITTING PARAMETERS FOR P=A*T**(-1)+B*T**(-.5) ARE:  A=  3.39153554E-05       OMEGA=  1.42629648E-02
                                                          B=  9.37925093E-02
                      A AND B FOUND IN  24 ITERATIONS          MINIMUM OF S(A,B)=  1.14103719E-01

   GAUSS CRITERION OF GOODNESS OF FIT
      THE EQUATION WHICH BEST FITS THIS DATA IS:

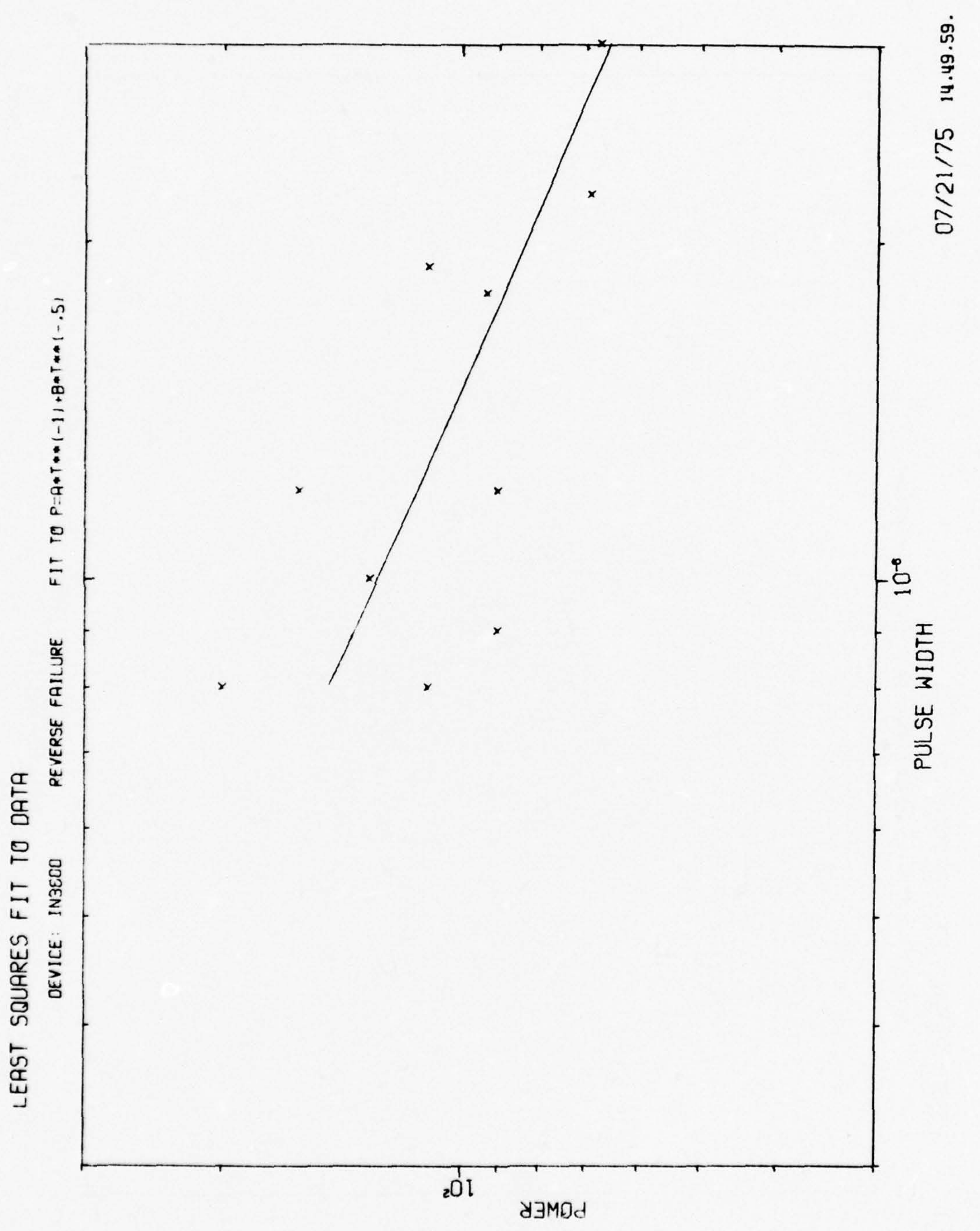
                      P=B*T**(-.5)
```

APPENDIX B


LEAST SQUARES FIT TO DATA
DEVICE: IN3600
REVERSE FAILURE
FIT TO P=A*T**(-1)
07/21/75 14.49.54.
PULSE WIDTH
10⁻⁶
POWER
10²


LEAST SQUARES FIT TO DATA
DEVICE: IN3600
REVERSE FAILURE
FIT TO P=B*T**(-.5)
07/21/75 14.49.56
PULSE WIDTH
10^{-6}
POWER
10^{2}

APPENDIX B



LEAST SQUARES FIT TO DATA
DEVICE: IN3600
REVERSE FAILURE
FIT TO P=A*T**(-1)+B*T**(-.5)
07/21/75 14.49.59.
PULSE WIDTH
10^{-8}
POWER
10^{2}

APPENDIX C.--LISTING OF SEMCON

This appendix contains a complete listing of SEMCON.

APPENDIX C

```
PROGRAM SEMCON      74/74    OPT=1                         FTN 4.5+414        06/01/76  14.04.49        PAGE     1

          PROGRAM SEMCON(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE1,TAPE7)  SEMCON    2
C                                                                            SEMCON    3
C                                                                            SEMCON    4
C         SEMI-CONDUCTOR DATA REDUCTION PROGRAM                              SEMCON    5
C                                                                            SEMCON    6
C                                                                            SEMCON    7
          INTEGER FLAG,FAIL,PULSE                                            SEMCON    8
          REAL IP,JUNC,MAN1,MAN2                                             SEMCON    9
          REAL IPRF,IPFF                                                     SEMCON   10
          COMMON PIN(600),P(600),TD(600),E(600),TDDC(600),Z(600),VOC(600),   SEMCON   11
         1       IP(600),FAIL(600)                                           SEMCON   12
          COMMON/A/IND,FLAG,IPRAM,DEV                                        SEMCON   13
          COMMON/B/PRF(600),TDRF(600),ERF(600),TDDCRF(600),ZRF(600),         SEMCON   14
         1       VOCRF(600),IPRF(600),P1(600),P2(600),P3(600)                SEMCON   15
          COMMON/C/PFF(600),TDFF(600),EFF(600),TDDCFF(600),ZFF(600),         SEMCON   16
         1       VOCFF(600),IPFF(600)                                        SEMCON   17
          COMMON/D/T(600),PP(600)                                            SEMCON   18
          COMMON/E/GAUS(3),S                                                 SEMCON   19
          COMMON/F/IPLOT,ISEM,ITYPE                                          SEMCON   20
          COMMON/G/DEVTYP1,DEVTYP2,JUNC,MAN1,MAN2,TECH,DATEE,ISTOP           SEMCON   21
          DIMENSION NPULS(300),VP(600),VZBP(600),VZAP(600),VZBN(600),        SEMCON   22
         1       VZAN(600),REMAR1(600),REMAR2(600),GAINB(600),               SEMCON   23
         2       GAINA(600),NDEV(600),PULSE(600)                             SEMCON   24
          PRINT 10                                                           SEMCON   25
   10     FORMAT(1H1)                                                        SEMCON   26
          CALL DATE(DAT)                                                     SEMCON   27
          CALL TIME(TIM)                                                     SEMCON   28
          PRINT 20,DAT,TIM                                                   SEMCON   29
   20     FORMAT(/,/,1X,44H SEMI-CONDUCTOR DAMAGE PROGRAM - VERSION OF ,     SEMCON   30
         112HJUNE,1975    ,33X,A10,5X,A10,/,/,/)                             SEMCON   31
          READ(5,25) IND,FLAG,IPRAM,ISTOP,IPLOT,ISEM,ITYPE                   SEMCON   32
   25     FORMAT(4(9X,I1),8X,I2,2(9X,I1))                                    SEMCON   33
          READ(5,30) NUMB,DEV,DEVTYP1,DEVTYP2,JUNC,MAN1,MAN2,TECH,DATEE      SEMCON   34
   30     FORMAT(I3,A8,2A10,A9,4A10)                                         SEMCON   35
          IF(ISTOP.NE.1)  WRITE(6,33)                                        SEMCON   36
   33     FORMAT(17HPM THIS JOB PLOTS)                                       SEMCON   37
          IF(ISEM.EQ.0)  GO TO 35                                            SEMCON   38
          CALL OWNDAT(NUMB)                                                  SEMCON   39
          GO TO 210                                                          SEMCON   40
   35     L=0                                                                SEMCON   41
          DO 70 I=1,NUMB                                                     SEMCON   42
          READ(5,40) NPULS(I)                                                SEMCON   43
   40     FORMAT(I2)                                                         SEMCON   44
          NPUL=NPULS(I)                                                      SEMCON   45
          DO 70 J=1,NPUL                                                     SEMCON   46
          L=L+1                                                              SEMCON   47
          READ(5,50) NDEV(L),PULSE(L),TDDC(L),VOC(L),VP(L),IP(L),            SEMCON   48
         1TD(L),VZBP(L)                                                      SEMCON   49
   50     FORMAT(I3,I2,E10.3,F10.3,F10.3,F10.3,E10.3,F10.3)                  SEMCON   50
          READ(5,60) VZAP(L),VZBN(L),VZAN(L),GAINB(L),GAINA(L),PIN(L),       SEMCON   51
         1REMAR1(L),REMAR2(L)                                                SEMCON   52
   60     FORMAT(3F10.3,2(2PE10.2),A2,A10,A9)                                SEMCON   53
   70     CONTINUE                                                           SEMCON   54
          NUM=L                                                              SEMCON   55
          DO 90 K=1,NUM                                                      SEMCON   56
          P(K)=0.                                                            SEMCON   57
          E(K)=0.                                                            SEMCON   58
```

APPENDIX C


```
      Z(K)=0.                                                           SEMCON   59
      IF(IP(K).LE.0) GO TO 80                                           SEMCON   60
      IF(VP(K).LE.0) GO TO 80                                           SEMCON   61
      P(K)=VP(K)*IP(K)                                                  SEMCON   62
      E(K)=P(K)*TD(K)                                                   SEMCON   63
      Z(K)=(VP(K)-VZBP(K))/IP(K)                                        SEMCON   64
      IF(Z(K).LT.0.) Z(K)=0.                                            SEMCON   65
   80 CALL FAILUR(VZBP(K),VZAP(K),FAIL(K))                              SEMCON   66
      IF(FAIL(K).EQ.3HYES) GO TO 90                                     SEMCON   67
      CALL FAILUR(VZBN(K),VZAN(K),FAIL(K))                              SEMCON   68
      IF(FAIL(K).EQ.3HYES) GO TO 90                                     SEMCON   69
      CALL FAILUR(GAINB(K),GAINA(K),FAIL(K))                            SEMCON   70
   90 CONTINUE                                                          SEMCON   71
      IF(ISTOP.EQ.3)  GO TO 145                                         SEMCON   72
      PRINT 100,DEV,DEVTYP1,DEVTYP2,JUNC,MAN1,MAN2,TECH,DATEE           SEMCON   73
  100 FORMAT(5X,8HDEVICE: ,A8,3X,13HDEVICE TYPE: ,2A10,3X,              SEMCON   74
     110HJUNCTION: ,A9,/,5X,14HMANUFACTURER: ,2A10,3X,12HTECHNICIAN: ,  SEMCON   75
     2A10,3X,6HDATE: ,A10,/,/)                                          SEMCON   76
      PRINT 110                                                         SEMCON   77
  110 FORMAT(1X,3HNO.,1X,2HPT,3X,4HTDOC,6X,3HVDC,4X,2HVP,4X,2HIP,5X,    SEMCON   78
     12HTD,6X,5HPOWER,3X,6HENERGY,1X,9HIMPEDANCE,2X,4HVZB+,2X,4HVZA+,   SEMCON   79
     22X,4HVZB-,2X,4HVZA-,2X,5HGAINB,1X,5HGAINA,1X,3HPIN,1X,4HFAIL,5X,  SEMCON   80
     37HREMARKS)                                                        SEMCON   81
      PRINT 120                                                         SEMCON   82
  120 FORMAT(1X,3H---,1X,2H--,3X,4H----,6X,3H---,4X,2H--,4X,2H--,5X,    SEMCON   83
     12H--,6X,5H-----,3X,6H------,1X,9H---------,2X,4H----,2X,4H----,   SEMCON   84
     22X,4H----,2X,4H----,2X,5H-----,1X,5H-----,1X,3H---,1X,4H----,5X,  SEMCON   85
     37H-------)                                                        SEMCON   86
      L=0                                                               SEMCON   87
      DO 140 I=1,NUMB                                                   SEMCON   88
      NPUL=NPULS(I)                                                     SEMCON   89
      DO 140 J=1,NPUL                                                   SEMCON   90
      L=L+1                                                             SEMCON   91
      PRINT 130,NDEV(L),PULSE(L),TDOC(L),VDC(L),VP(L),IP(L),TD(L),P(L), SEMCON   92
     1E(L),Z(L),VZBP(L),VZAP(L),VZBN(L),VZAN(L),GAINB(L),GAINA(L),      SEMCON   93
     2PIN(L),FAIL(L),REMAR1(L),REMAR2(L)                                SEMCON   94
  130 FORMAT(1H ,I3,1H-,I2,1X,E8.2,1X,F6.1,1X,F6.1,1X,F5.1,1X,E8.2,     SEMCON   95
     11X,E8.2,1X,E8.2,1X,E8.2,1X,F5.1,1X,F5.1,1X,F5.1,1X,F5.1,1X,       SEMCON   96
     2F6.2,1X,F5.1,1X,A2,1X,A3,1X,A10,A9)                               SEMCON   97
  140 CONTINUE                                                          SEMCON   98
      IF(ISTOP.EQ.1)  GO TO 210                                         SEMCON   99
  145 CONTINUE                                                          SEMCON  100
      PRINT 150                                                         SEMCON  101
  150 FORMAT(1H1)                                                       SEMCON  102
      CALL FRFAIL(NUM,KNUM,JNUM)                                        SEMCON  103
      IF(IPRAM.EQ.4)  GO TO 160                                         SEMCON  104
      IF(IPRAM.NE.0)  GO TO 200                                         SEMCON  105
  160 GO TO (170,180,170),IND                                           SEMCON  106
  170 CALL DIRECT(KNUM,1,A,B,AE,BE,IT)                                  SEMCON  107
      CALL WRITE(A,B,AE,BE,1,IT)                                        SEMCON  108
      CALL GAUSS                                                        SEMCON  109
      CALL PLOTT(KNUM,JNUM,1)                                           SEMCON  110
      IF(IND.EQ.1)  GO TO 190                                           SEMCON  111
  180 IF(JNUM.EQ.0)  GO TO 190                                          SEMCON  112
      CALL DIRECT(JNUM,2,A,B,AE,BE,IT)                                  SEMCON  113
      CALL WRITE(A,B,AE,BE,2,IT)                                        SEMCON  114
      CALL GAUSS                                                        SEMCON  115
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      PROGRAM SEMCON      74/74    OPT=1                             FTN 4.5+414        06/01/76  14.04.49        PAGE     3

                     CALL PLOTT(KNUM,JNUM,2)                                                   SEMCON     116
                190 CONTINUE                                                                   SEMCON     117
                     IF(IPRAM.EQ.0)  GO TO 210                                                 SEMCON     118
                200 CALL PLOTT(KNUM,JNUM,3)                                                    SEMCON     119
                210 STOP                                                                       SEMCON     120
                     END                                                                       SEMCON     121


CARD NR. SEVERITY  DETAILS     DIAGNOSIS OF PROBLEM

     105    I               AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.


        SYMBOLIC REFERENCE MAP (R=3)

 ENTRY POINTS     DEF LINE      REFERENCES
 10215  SEMCON        1

 VARIABLES      SN  TYPE             RELOCATION
 11153  A          REAL                                 REFS       106        107        112        113
 11155  AE         REAL                                 REFS       106        107        112        113
 11154  B          REAL                                 REFS       106        107        112        113
 11156  BE         REAL                                 REFS       106        107        112        113
 11140  DAT        REAL                                 REFS        26         28
     6  DATEE      REAL                  G              REFS        20         72    DEFINED         33
     3  DEV        REAL                  A              REFS        12         72    DEFINED         33
     0  DEVTYP1    REAL                  G              REFS        20         72    DEFINED         33
     1  DEVTYP2    REAL                  G              REFS        20         72    DEFINED         33
  3410  E          REAL       ARRAY      / /            REFS        10         91    DEFINED         57         62
  2260  EFF        REAL       ARRAY      C              REFS        15
  2260  ERF        REAL       ARRAY      B              REFS        13
 11300  FAIL       INTEGER    ARRAY      / /            REFS         7         10         65         66         67         68         69
                                                          91
     1  FLAG       INTEGER               A              REFS         7         12    DEFINED         31
 24264  GAINA      REAL       ARRAY                     REFS        21         69         91    DEFINED         50
 23134  GAINB      REAL       ARRAY                     REFS        21         69         91    DEFINED         50
     0  GAUS       REAL       ARRAY      E              REFS        18
 11144  I          INTEGER                              REFS        42         44         88    DEFINED         41         87
     0  IND        INTEGER               A              REFS        12        105        110    DEFINED         31
 10150  IP         REAL       ARRAY      / /            REFS         8         10         59         61         63         91
                                                     DEFINED        47
  7020  IPFF       REAL       ARRAY      C              REFS         9         15
     0  IPLOT      INTEGER               F              REFS        19    DEFINED         31
     2  IPRAM      INTEGER               A              REFS        12        103        104        117    DEFINED         31
  7020  IPRF       REAL       ARRAY      B              REFS         9         13
     1  ISEM       INTEGER               F              REFS        19         37    DEFINED         31
     7  ISTOP      INTEGER               G              REFS        20         35         71         98    DEFINED         31
 11157  IT         INTEGER                              REFS       106        107        112        113
     2  ITYPE      INTEGER               F              REFS        19    DEFINED         31
 11146  J          INTEGER                           DEFINED        45         89
 11152  JNUM       INTEGER                              REFS       102        109        111        112        115        118
     2  JUNC       REAL                  G              REFS         8         20         72    DEFINED         33
```

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         PROGRAM SEMCON     74/74   OPT=1                               FTN 4.5+424      06/01/76  14.04.49      PAGE     4

VARIABLES       SN  TYPE              RELOCATION
11150  K            INTEGER                           REFS       56      57       58       59       60      3*61    3*62
                                                       4*63    2*64    3*65       66     3*67       68      3*69
                                                    DEFINED      55
11151  KNUM         INTEGER                           REFS      102     106      109      115      118
11143  L            INTEGER                           REFS       46    8*47     8*50       54       90     20*91
                                                    DEFINED      40      46       86       90
    3  MAN1         REAL                G             REFS        8      20       72  DEFINED       33
    4  MAN2         REAL                G             REFS        8      20       72  DEFINED       33
25414  NDEV         INTEGER    ARRAY                  REFS       21      91  DEFINED       47
11145  NPUL         INTEGER                           REFS       45      89  DEFINED       44       88
12310  NPULS        INTEGER    ARRAY                  REFS       21      44       88  DEFINED       42
11147  NUM          INTEGER                           REFS       55     102  DEFINED       54
11142  NUMB         INTEGER                           REFS       38      41       87  DEFINED       33
 1130  P            REAL       ARRAY    / /           REFS       10      62       91  DEFINED       56       61
    0  PFF          REAL       ARRAY    C             REFS       15
    0  PIN          REAL       ARRAY    / /           REFS       10      91  DEFINED       50
 1130  PP           REAL       ARRAY    D             REFS       17
    0  PRF          REAL       ARRAY    B             REFS       13
11160  PULSE        INTEGER    ARRAY                  REFS        7      21       91  DEFINED       47
10150  P1           REAL       ARRAY    B             REFS       13
11300  P2           REAL       ARRAY    B             REFS       13
12430  P3           REAL       ARRAY    B             REFS       13
20654  REMAR1       REAL       ARRAY                  REFS       21      91  DEFINED       50
22004  REMAR2       REAL       ARRAY                  REFS       21      91  DEFINED       50
    3  S            REAL                E             REFS       18
    0  T            REAL       ARRAY    D             REFS       17
 2260  TD           REAL       ARRAY    / /           REFS       10      62       91  DEFINED       47
 1130  TDFF         REAL       ARRAY    C             REFS       15
 4540  TDOC         REAL       ARRAY    / /           REFS       10      91  DEFINED       47
 3410  TDOCFF       REAL       ARRAY    C             REFS       15
 3410  TDOCRF       REAL       ARRAY    B             REFS       13
 1130  TDRF         REAL       ARRAY    B             REFS       13
    5  TECH         REAL                G             REFS       20      72  DEFINED       33
11141  TIM          REAL                              REFS       27      28
 7020  VDC          REAL       ARRAY    / /           REFS       10      91  DEFINED       47
 5670  VDCFF        REAL       ARRAY    C             REFS       15
 5670  VDCRF        REAL       ARRAY    B             REFS       13
12764  VP           REAL       ARRAY                  REFS       21      60       61       63       91
                                                    DEFINED      47
17524  VZAN         REAL       ARRAY                  REFS       21      67       91  DEFINED       50
15244  VZAP         REAL       ARRAY                  REFS       21      65       91  DEFINED       50
16374  VZBN         REAL       ARRAY                  REFS       21      67       91  DEFINED       50
14114  VZBP         REAL       ARRAY                  REFS       21      63       65       91  DEFINED       47
 5670  Z            REAL       ARRAY    / /           REFS       10      64       91  DEFINED       58       63       64
 4540  ZFF          REAL       ARRAY    C             REFS       15
 4540  ZRF          REAL       ARRAY    B             REFS       13

FILE NAMES          MODE
    0  INPUT
 2041  OUTPUT       FMT                     WRITES       24      28      72       76       81       91      100
 4102  TAPE1
    0  TAPE5        FMT                      READS       31      33      42       47       50
 2041  TAPE6        FMT                     WRITES       35
 6143  TAPE7
```

```
         PROGRAM SEMCON      74/74    OPT=1                         FTN 4.5+414        06/01/76  14.04.49       PAGE     5
EXTERNALS            TYPE    ARGS      REFERENCES
          DATE                1             26
          DIRECT              7            106       112
          FAILUR              3             65        67        69
          FRFAIL              3            102
          GAUSS               0            108       114
          OWNDAT              1             38
          PLOTT               3            109       115       118
          TIME                1             27
          WRITE               6            107       113

STATEMENT LABELS                  DEF LINE     REFERENCES
10621  10         FMT               25           24
10630  20         FMT               29           28
10655  25         FMT               32           31
10676  30         FMT               34           33
10704  33         FMT               36           35
10242  35                           40           37
10715  40         FMT               43           42
10733  50         FMT               49           47
10755  60         FMT               52           50
    0  70                           53           41        45
10336  80                           65           59        60
10361  90                           70           55        66        68
10774  100        FMT               73           72
11014  110        FMT               77           76
11040  120        FMT               82           81
11110  130        FMT               94           91
    0  140                          97           87        89
10452  145                          99           71
11131  150        FMT              101          100
10461  160                         105          103
10471  170                         106        2*105
10502  180                         111          105
10512  190                         116          110       111
10513  200                         118          104
10515  210                         119           39        98       117

LOOPS  LABEL     INDEX      FROM-TO     LENGTH     PROPERTIES
10244  70         * I        41 53       55B                  EXT REFS  NOT INNER
10254  70         * J        45 53       43B                  EXT REFS
10324  90         * K        55 70       40B                  EXT REFS
10375  140        * I        87 97       53B                  EXT REFS  NOT INNER
10400  140        * J        89 97       46B                  EXT REFS

COMMON BLOCKS   LENGTH      MEMBERS - BIAS NAME(LENGTH)
   / /           5400             0 PIN      (600)        600 P       (600)        1200 TD      (600)
                               1800 E        (600)       2400 TDOC    (600)        3000 Z       (600)
                               3600 VOC      (600)       4200 IP      (600)        4800 FAIL    (600)
   A                4             0 IND      (1)            1 FLAG    (1)             2 IPRAM   (1)
                                  3 DEV      (1)
   B             6000             0 PRF      (600)        600 TDRF    (600)        1200 ERF     (600)
                               1800 TDOCRF   (600)       2400 ZRF     (600)        3000 VOCRF   (600)
                               3600 IPRF     (600)       4200 P1      (600)        4800 P2      (600)
                               5400 P3       (600)
   C             4200             0 PFF      (600)        600 TOFF    (600)        1200 EFF     (600)
                               1800 TDOCFF   (600)       2400 ZFF     (600)        3000 VOCFF   (600)
                               3600 IPFF     (600)
```

APPENDIX C

```
        PROGRAM SEMCON      74/74    OPT=1                         FTN 4.5+414        06/01/76  14.04.49        PAGE     6

COMMON BLOCKS   LENGTH     MEMBERS - BIAS NAME(LENGTH)
       D         1200                0 T       (600)            600 PP      (600)
       E            4                0 GAUS    (3)                3 S       (1)
       F            3                0 IPLOT   (1)                1 ISEM    (1)              2 ITYPE   (1)
       G            8                0 DEVTYP1(1)                 1 DEVTYP2(1)               2 JUNC    (1)
                                     3 MAN1    (1)                4 MAN2    (1)              5 TECH    (1)
                                     6 DATEE   (1)                7 ISTOP   (1)

STATISTICS
  PROGRAM LENGTH                16337B     7391
  BUFFER LENGTH                 10205B     4229
  CM LABELED COMMON LENGTH      26233B    11419
  CM BLANK COMMON LENGTH        12430B     5400
```

```
SUBROUTINE FAILUR     74/74   OPT=1                       FTN 4.5+414      06/01/76  14.04.49      PAGE     1

                      SUBROUTINE FAILUR (R,S,N)                             FAILUR       2
                      REAL N                                                FAILUR       3
                      N=3H NO                                               FAILUR       4
                      IF(R.LE.O.) RETURN                                    FAILUR       5
                      IF(.9*R-S.GT.C.) N=3HYES                              FAILUR       6
                      RETURN                                                FAILUR       7
                      END                                                   FAILUR       8


   SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
   3  FAILUR         1             4        6

VARIABLES      SN  TYPE            RELOCATION
   O  N            REAL                F.P.     REFS      2  DEFINED       1          3        5
   O  R            REAL                F.P.     REFS      4       5   DEFINED         1
   O  S            REAL                F.P.     REFS      5  DEFINED       1

STATISTICS
  PROGRAM LENGTH                 20B      16
```

```
SUBROUTINE FRFAIL      74/74    OPT=1                          FTN 4.5+414       06/01/76  14.04.49       PAGE     1

            SUBROUTINE FRFAIL(NUM,KNUM,JNUM)
            REAL IPRF,IPFF                                                          FRFAIL     2
            REAL IP                                                                 FRFAIL     3
            COMMON PIN(600),P(600),TD(600),E(600),TDDC(600),Z(600),VDC(600),        FRFAIL     4
           1       IP(600),FAIL(600)                                                FRFAIL     5
            COMMON/B/PRF(600),TDRF(600),ERF(600),TDDCRF(600),ZRF(600),              FRFAIL     6
           1         VDCRF(600),IPRF(600),P1(600),P2(600),P3(600)                   FRFAIL     7
            COMMON/C/PFF(600),TDFF(600),EFF(600),TDDCFF(600),ZFF(600),              FRFAIL     8
           1         VDCFF(600),IPFF(600)                                           FRFAIL     9
            K=1                                                                     FRFAIL    10
            J=1                                                                     FRFAIL    11
            DO 30 I=1,NUM                                                           FRFAIL    12
            IF(FAIL(I).EQ.3H NO)  GO TO 30                                          FRFAIL    13
            IF(PIN(I).EQ.2HC+)  GO TO 10                                            FRFAIL    14
            IF(PIN(I).EQ.2HA+)  GO TO 20                                            FRFAIL    15
            GO TO 30                                                                FRFAIL    16
         10 TDRF(K)=TD(I)                                                           FRFAIL    17
            PRF(K)=P(I)                                                             FRFAIL    18
            ERF(K)=E(I)                                                             FRFAIL    19
            ZRF(K)=Z(I)                                                             FRFAIL    20
            VDCRF(K)=VDC(I)                                                         FRFAIL    21
            IPRF(K)=IP(I)                                                           FRFAIL    22
            TDDCRF(K)=TDDC(I)                                                       FRFAIL    23
            K=K+1                                                                   FRFAIL    24
            GO TO 30                                                                FRFAIL    25
         20 TDFF(J)=TD(I)                                                           FRFAIL    26
            PFF(J)=P(I)                                                             FRFAIL    27
            EFF(J)=E(I)                                                             FRFAIL    28
            ZFF(J)=Z(I)                                                             FRFAIL    29
            VDCFF(J)=VDC(I)                                                         FRFAIL    30
            IPFF(J)=IP(I)                                                           FRFAIL    31
            TDDCFF(J)=TDDC(I)                                                       FRFAIL    32
            J=J+1                                                                   FRFAIL    33
            GO TO 30                                                                FRFAIL    34
         30 CONTINUE                                                                FRFAIL    35
            KNUM=K-1                                                                FRFAIL    36
            JNUM=J-1                                                                FRFAIL    37
            RETURN                                                                  FRFAIL    38
            END                                                                     FRFAIL    39
                                                                                    FRFAIL    40

     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE     REFERENCES
    3  FRFAIL        1           38

VARIABLES      SN  TYPE            RELOCATION
  3410  E          REAL       ARRAY    / /        REFS      4       19      28
  2260  EFF        REAL       ARRAY    C          REFS      8  DEFINED      28
  2260  ERF        REAL       ARRAY    B          REFS      6  DEFINED      19
 11300  FAIL       REAL       ARRAY    / /        REFS      4       13
    65  I          INTEGER                        REFS     13       14      15      17      18      19      20
                                                     21    22       23      26      27      28      29      30
                                                     31    32  DEFINED      12
```

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        SUBROUTINE FRFAIL      74/74   OPT=1                                FTN 4.5+414       06/01/76  14.04.49        PAGE     2

VARIABLES       SN  TYPE              RELOCATION
10150  IP           REAL        ARRAY     / /           REFS          3          4        22         31
 7020  IPFF         REAL        ARRAY     C             REFS          2          8    DEFINED        31
 7020  IPRF         REAL        ARRAY     B             REFS          2          6    DEFINED        22
   64  J            INTEGER                             REFS         26         27        28         29         30         31         32
                                                           33        37    DEFINED        11         33
    0  JNUM         INTEGER              F.P.         DEFINED         1         37
   63  K            INTEGER                             REFS         17         18        19         20         21         22         23
                                                           24        36    DEFINED        10         24
    0  KNUM         INTEGER              F.P.         DEFINED         1         36
    0  NUM          INTEGER              F.P.           REFS         12    DEFINED         1
 1130  P            REAL        ARRAY     / /           REFS          4         18        27
    0  PFF          REAL        ARRAY     C             REFS          8    DEFINED        27
    0  PIN          REAL        ARRAY     / /           REFS          4         14        15
    0  PRF          REAL        ARRAY     B             REFS          6    DEFINED        18
10150  P1           REAL        ARRAY     B             REFS          6
11300  P2           REAL        ARRAY     B             REFS          6
12430  P3           REAL        ARRAY     B             REFS          6
 2260  TD           REAL        ARRAY     / /           REFS          4         17        26
 1130  TDFF         REAL        ARRAY     C             REFS          8    DEFINED        26
 4540  TDDC         REAL        ARRAY     / /           REFS          4         23        32
 3410  TDDCFF       REAL        ARRAY     C             REFS          8    DEFINED        32
 3410  TDDCRF       REAL        ARRAY     B             REFS          6    DEFINED        23
 1130  TDRF         REAL        ARRAY     B             REFS          6    DEFINED        17
 7020  VDC          REAL        ARRAY     / /           REFS          4         21        30
 5670  VDCFF        REAL        ARRAY     C             REFS          8    DEFINED        30
 5670  VDCRF        REAL        ARRAY     B             REFS          6    DEFINED        21
 5670  Z            REAL        ARRAY     / /           REFS          4         20        29
 4540  ZFF          REAL        ARRAY     C             REFS          8    DEFINED        29
 4540  ZRF          REAL        ARRAY     B             REFS          6    DEFINED        20

STATEMENT LABELS                DEF LINE    REFERENCES
   22  10                          17          14
   35  20                          26          15
   50  30                          35          12         13         16         25        34

LOOPS  LABEL    INDEX       FROM-TO     LENGTH     PROPERTIES
   14  30       I            12 35       35B          OPT

COMMON BLOCKS   LENGTH      MEMBERS - BIAS NAME(LENGTH)
     / /         5400                 0 PIN     (600)           600 P       (600)          1200 TD      (600)
                                   1800 E       (600)          2400 TDDC    (600)          3000 Z       (600)
                                   3600 VDC     (600)          4200 IP      (600)          4800 FAIL    (600)
     B           6000                 0 PRF     (600)           600 TDRF    (600)          1200 ERF     (600)
                                   1800 TDDCRF  (600)          2400 ZRF     (600)          3000 VDCRF   (600)
                                   3600 IPRF    (600)          4200 P1      (600)          4800 P2      (600)
                                   5400 P3      (600)
     C           4200                 0 PFF     (600)           600 TDFF    (600)          1200 EFF     (600)
                                   1800 TDDCFF  (600)          2400 ZFF     (600)          3000 VDCFF   (600)
                                   3600 IPFF    (600)

STATISTICS
  PROGRAM LENGTH                  66B       54
  CM LABELED COMMON LENGTH     23730B    10200
  CM BLANK COMMON LENGTH       12430B     5400
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SUBROUTINE DIRECT      74/74    OPT=1                          FTN 4.5+414        06/01/76  14.04.49        PAGE     1

 1                 SUBROUTINE DIRECT(N,M,A,B,AE,BE,IT)                                  DIRECT      2
 2                 INTEGER FLAG                                                         DIRECT      3
 3                 REAL IPRF,IPFF                                                       DIRECT      4
 4                 COMMON/A/IND,FLAG,IPRAM,DEV                                          DIRECT      5
 5                 COMMON/B/PRF(600),TDRF(600),ERF(600),TDOCRF(600),ZRF(600),           DIRECT      6
 6                1          VOCRF(600),IPRF(600),P1(600),P2(600),P3(600)               DIRECT      7
 7                 COMMON/C/PFF(600),TDFF(600),EFF(600),TDOCFF(600),ZFF(600),           DIRECT      8
 8                1          VOCFF(600),IPFF(600)                                       DIRECT      9
 9                 COMMON/D/T(600),PP(600)                                              DIRECT     10
10                 J=1                                                                  DIRECT     11
11                 K=1                                                                  DIRECT     12
12                 GO TO (10,30,55),M                                                   DIRECT     13
13              10 DO 20 I=1,N                                                          DIRECT     14
14                 IF(PRF(I).EQ.0.)  GO TO 15                                           DIRECT     15
15                 T(J)=TDRF(I)                                                         DIRECT     16
16                 PP(J)=PRF(I)                                                         DIRECT     17
17                 J=J+1                                                                DIRECT     18
18              15 IF(I.EQ.N.AND.PRF(I).EQ.0.)  J=J+1                                   DIRECT     19
19              20 CONTINUE                                                             DIRECT     20
20                 N=J-1                                                                DIRECT     21
21                 GO TO 50                                                             DIRECT     22
22              30 DO 40 I=1,N                                                          DIRECT     23
23                 IF(PFF(I).EQ.0.)  GO TO 35                                           DIRECT     24
24                 T(K)=TDFF(I)                                                         DIRECT     25
25                 PP(K)=PFF(I)                                                         DIRECT     26
26                 K=K+1                                                                DIRECT     27
27              35 IF(I.EQ.N.AND.PFF(I).EQ.0.)  K=K+1                                   DIRECT     28
28              40 CONTINUE                                                             DIRECT     29
29                 N=K-1                                                                DIRECT     30
30              50 CALL SORT(N)                                                         DIRECT     31
31              55 GO TO (60,70,60),FLAG                                                DIRECT     32
32              60 CALL ALSQAR(N,A)                                                     DIRECT     33
33                 CALL GOODFIT(PP,P2,N,1,1)                                            DIRECT     34
34                 CALL BLSQAR(N,B)                                                     DIRECT     35
35                 CALL GOODFIT(PP,P3,N,1,2)                                            DIRECT     36
36                 IF(FLAG.EQ.1)  GO TO 80                                              DIRECT     37
37              70 IF(FLAG.EQ.3)  GO TO 75                                              DIRECT     38
38                 CALL ALSQAR(N,A)                                                     DIRECT     39
39                 CALL BLSQAR(N,B)                                                     DIRECT     40
40              75 CALL ABLSQAR(N,A,B,AE,BE,IT)                                         DIRECT     41
41                 CALL GOODFIT(PP,P1,N,2,3)                                            DIRECT     42
42              80 CONTINUE                                                             DIRECT     43
43                 RETURN                                                               DIRECT     44
44                 END                                                                  DIRECT     45


CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

   12     I                   AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   31     I                   AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
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SUBROUTINE DIRECT     74/74   OPT=1                          FTN 4.5+414      06/01/76  14.04.49      PAGE     2

SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE     REFERENCES
   3  DIRECT        1            43

VARIABLES        SN  TYPE                RELOCATION
     0  A             REAL                      F.P.     REFS       32        38       40    DEFINED       1
     0  AE            REAL                      F.P.     REFS       40   DEFINED        1
     0  B             REAL                      F.P.     REFS       34        33       40    DEFINED       1
     0  BE            REAL                      F.P.     REFS       40   DEFINED        1
     3  DEV           REAL                  A            REFS        4
  2260  EFF           REAL       ARRAY      C            REFS        7
  2260  ERF           REAL       ARRAY      B            REFS        5
     1  FLAG          INTEGER               A            REFS        2         4       31      36         37
   214  I             INTEGER                            REFS       14        15       16      2*18       23       24       25
                                                         2*27  DEFINED        13       22
     0  IND           INTEGER               A            REFS        4
  7020  IPFF          REAL       ARRAY      C            REFS        3         7
     2  IPRAM         INTEGER               A            REFS        4
  7020  IPRF          REAL       ARRAY      B            REFS        3         5
     0  IT            INTEGER                   F.P.     REFS       40   DEFINED        1
   212  J             INTEGER                            REFS       15        16       17      18         20
                                                      DEFINED       10        17       18
   213  K             INTEGER                            REFS       24        25       26      27         29
                                                      DEFINED       11        26       27
     0  M             INTEGER                   F.P.     REFS       12   DEFINED        1
     0  N             INTEGER                   F.P.     REFS       13        18       22      27         30       32       33
                                                           34       35        38       39      40         41
                                                      DEFINED        1        20       29
     0  PFF           REAL       ARRAY      C            REFS        7        23       25      27
  1130  PP            REAL       ARRAY      D            REFS        9        33       35      41    DEFINED       16       25
     0  PRF           REAL       ARRAY      B            REFS        5        14       16      18
 10150  P1            REAL       ARRAY      B            REFS        5        41
 11300  P2            REAL       ARRAY      B            REFS        5        33
 12430  P3            REAL       ARRAY      B            REFS        5        35
     0  T             REAL       ARRAY      D            REFS        9   DEFINED       15      24
  1130  TDFF          REAL       ARRAY      C            REFS        7        24
  3410  TDDCFF        REAL       ARRAY      C            REFS        7
  3410  TDDCRF        REAL       ARRAY      B            REFS        5
  1130  TDRF          REAL       ARRAY      B            REFS        5        15
  5670  VDCFF         REAL       ARRAY      C            REFS        7
  5670  VDCRF         REAL       ARRAY      B            REFS        5
  4540  ZFF           REAL       ARRAY      C            REFS        7
  4540  ZRF           REAL       ARRAY      B            REFS        5

EXTERNALS           TYPE     ARGS        REFERENCES
      ABLSQAR                  6             40
      ALSQAR                   2             32        38
      BLSQAR                   2             34        39
      GOODFIT                  5             33        35       41
      SORT                     1             30

STATEMENT LABELS              DEF LINE     REFERENCES
    17  10                       13            12
    30  15                       18            14
     0  20                       19            13
    41  30                       22            12
```

APPENDIX C

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        SUBROUTINE DIRECT       74/74    OPT=1                         FTN 4.5+414        06/01/76  14.04.49        PAGE      3

 STATEMENT LABELS                      DEF LINE    REFERENCES
     52  35                               27          23
      0  40                               28          22
     63  50                               30          21
     66  55                               31          12
     76  60                               32          2*31
    116  70                               37          31
    130  75                               40          37
    145  80                               42          36

 LOOPS  LABEL       INDEX        FROM-TO      LENGTH       PROPERTIES
    24  20          I             13 19        11B            OPT
    46  40          I             22 28        11B            OPT

 COMMON BLOCKS   LENGTH       MEMBERS - BIAS NAME(LENGTH)
        A             4                0 IND        (1)                 1 FLAG      (1)                 2 IPRAM   (1)
                                       3 DEV        (1)
        B          6000                0 PRF        (600)             600 TDRF      (600)            1200 ERF     (600)
                                    1800 TDDCRF     (600)            2400 ZRF       (600)            3000 VDCRF   (600)
                                    3600 IPRF       (600)            4200 P1        (600)            4800 P2      (600)
                                    5400 P3         (600)
        C          4200                0 PFF        (600)             600 TDFF      (600)            1200 EFF     ( 00
                                    1800 TDDCFF     (600)            2400 ZFF       (600)            3000 VDCFF   (6C
                                    3600 IPFF       (600)
        D          1200                0 T          (600)             600 PP        (600)

 STATISTICS
   PROGRAM LENGTH                    215B       141
   CM LABELED COMMON LENGTH        26214B     11404
```

```
SUBROUTINE WRITE       74/74    OPT=1                              FTN 4.5+414        06/01/76  14.04.49        PAGE     1

  1              SUBROUTINE WRITE(A,B,AE,BE,M,IT)                                    WRITE        2
                 INTEGER FLAG                                                        WRITE        3
                 COMMON/A/IND,FLAG,IPRAM,DEV                                         WRITE        4
                 COMMON/E/GAUS(3),S                                                  WRITE        5
  5              GO TO (10,30),M                                                     WRITE        6
              10 WRITE(6,20) DEV                                                     WRITE        7
              20 FORMAT(/,/,/,1X,43HREVERSE FAILURE CURVES AND DATA FOR DEVICE ,     WRITE        8
                1A8)                                                                 WRITE        9
                 GO TO 50                                                            WRITE       10
 10           30 WRITE(6,40) DEV                                                     WRITE       11
              40 FORMAT(/,/,/,1X,43HFORWARD FAILURE CURVES AND DATA FOR DEVICE ,     WRITE       12
                1A8)                                                                 WRITE       13
              50 GO TO (60,90,60),FLAG                                               WRITE       14
              60 WRITE(6,70) A,GAUS(1)                                               WRITE       15
 15           70 FORMAT(/,/,10X,42HFITTING PARAMETER FOR P=A*T**(-1) IS:  A= ,       WRITE       16
                11PE15.8,25X,7HOMEGA= ,1PE15.8)                                      WRITE       17
                 WRITE(6,80) B,GAUS(2)                                               WRITE       18
              80 FORMAT(/,/,10X,43HFITTING PARAMETER FOR P=B*T**(-.5) IS:  B= ,      WRITE       19
                11PE15.8,24X,7HOMEGA= ,1PE15.8)                                      WRITE       20
 20              IF(FLAG.EQ.1)  RETURN                                               WRITE       21
              90 WRITE(6,100) AE,GAUS(3),BE                                          WRITE       22
             100 FORMAT(/,/,10X,46HFITTING PARAMETERS FOR P=A*T**(-1)+B*T**(-.5) ,   WRITE       23
                19HARE:  A= ,1PE15.8,12X,7HOMEGA= ,1PE15.8,/,62X,3HB= ,1PE15.8)      WRITE       24
                 WRITE(6,110) IT,S                                                   WRITE       25
 25          110 FORMAT(/,30X,17HA AND B FOUND IN ,I3,11H ITERATIONS,                WRITE       26
                110X,19HMINIMUM OF S(A,B)= ,1PE15.8)                                 WRITE       27
                 RETURN                                                              WRITE       28
                 END                                                                 WRITE       29


CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

     5     I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    13     I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.


      SYMBOLIC REFERENCE MAP (R=3)

 ENTRY POINTS     DEF LINE     REFERENCES
     3  WRITE         1           20        27

 VARIABLES      SN  TYPE            RELOCATION
     0  A           REAL                 F.P.       REFS       14    DEFINED       1
     0  AE          REAL                 F.P.       REFS       21    DEFINED       1
     0  B           REAL                 F.P.       REFS       17    DEFINED       1
     0  BE          REAL                 F.P.       REFS       21    DEFINED       1
     3  DEV         REAL               A            REFS        3          6      10
     1  FLAG        INTEGER            A            REFS        2          3      13       20
     0  GAUS        REAL       ARRAY   E            REFS        4         14      17       21
     0  IND         INTEGER            A            REFS        3
     2  IPRAM       INTEGER            A            REFS        3
     0  IT          INTEGER              F.P.       REFS       24    DEFINED       1
```

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     SUBROUTINE WRITE       74/74   OPT=1                       FTN 4.5+414       06/01/76  14.04.49       PAGE     2

VARIABLES      SN  TYPE            RELOCATION
    0  M           INTEGER             F.P.        REFS        5   DEFINED        1
    3  S           REAL               E            REFS        4      24

FILE NAMES         MODE
     TAPE6        FMT                   WRITES        6         10         14         17         21         24

STATEMENT LABELS              DEF LINE    REFERENCES
   14  10                         6            5
   50  20         FMT             7            6
   17  30                        10            5
   63  40         FMT            11           10
   21  50                        13            9
   31  60                        14          2*13
   77  70         FMT            15           14
  115  80         FMT            18           17
   37  90                        21           13
  134  100        FMT            22           21
  156  110        FMT            25           24

COMMON BLOCKS    LENGTH     MEMBERS - BIAS NAME(LENGTH)
     A              4                 0 IND     (1)                 1 FLAG    (1)                 2 IPRAM  (1)
                                      3 DEV     (1)
     E              4                 0 GAUS    (3)                 3 S       (1)

STATISTICS
  PROGRAM LENGTH                  167B      119
  CM LABELED COMMON LENGTH         10B        8
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SUBROUTINE PLOTT      74/74    OPT=1                         FTN 4.5+414        06/01/76  14.04.49          PAGE      1

              SUBROUTINE PLOTT(KNUM,JNUM,J)                                      PLOT    2
              INTEGER FLAG                                                       PLOT    3
              REAL IP,IPRF,IPFF                                                  PLOT    4
              COMMON/A/IND,FLAG,IPRAM,DEV                                        PLOT    5
              COMMON/B/PRF(600),TDRF(600),ERF(600),TDDCRF(600),ZRF(600),         PLOT    6
             1          VOCRF(600),IPRF(600),P1(600),P2(600),P3(600)             PLOT    7
              COMMON/C/PFF(600),TDFF(600),EFF(600),TDDCFF(600),ZFF(600),         PLOT    8
             1          VOCFF(600),IPFF(600)                                     PLOT    9
              COMMON/D/T(600),PP(600)                                            PLOT   10
              COMMON/F/IPLOT,ISEM,ITYPE                                          PLOT   11
              DIMENSION RTITLEA(8),RTITLEB(8),ETITLER(8),RTITLAB(8),             PLOT   12
             1          FTITLEA(8),FTITLEB(8),ETITLEF(8),FTITLAB(8)              PLOT   13
              DIMENSION XTITLE(3),YTITLE(3),YTITLEE(3),XTITLEP(3),YTITLEZ(3),    PLOT   14
             1          YTITVOC(3),YTITLEI(3),LEGEN(3),BLANK(3)                  PLOT   15
              DATA RTITLEA/8*1H /,RTITLEB/8*1H /,ETITLER/8*1H /,RTITLAB/8*1H /,  PLOT   16
             1     FTITLEA/8*1H /,FTITLEB/8*1H /,ETITLEF/8*1H /,FTITLAB/8*1H /,  PLOT   17
             2     XTITLE/3*1H /,YTITLE/3*1H /,YTITLEE/3*1H /,XTITLEP/3*1H /,    PLOT   18
             3     YTITLEZ/3*1H /,YTITVOC/3*1H /,YTITLEI/3*1H /,LEGEN/3*1H /,    PLOT   19
             4     BLANK/3*1H /                                                  PLOT   20
              XTITLE(1)=5H                                                       PLOT   21
              XTITLE(2)=10HFAILURE TI                                            PLOT   22
              XTITLE(3)=10HME(TD)                                                PLOT   23
              YTITLE(1)=10H                                                      PLOT   24
              YTITLE(2)=10HPOWER(P)                                              PLOT   25
              YTITLEE(1)=10H                                                     PLOT   26
              YTITLEE(2)=10HENERGY(E)                                            PLOT   27
              ETITLER(1)=10H  DEVICE:                                            PLOT   28
              ETITLER(2)=DEV                                                     PLOT   29
              ETITLER(3)=10H   REVERSE                                           PLOT   30
              ETITLER(4)=10H FAILURE                                             PLOT   31
              XTITLEP(1)=10HPULSE DURA                                           PLOT   32
              XTITLEP(2)=10HTION(TDDC)                                           PLOT   33
              ETITLEF(1)=10H  DEVICE:                                            PLOT   34
              ETITLEF(2)=DEV                                                     PLOT   35
              ETITLEF(3)=10H   FORWARD                                           PLOT   36
              ETITLEF(4)=10H FAILURE                                             PLOT   37
              YTITLEZ(1)=5H                                                      PLOT   38
              YTITLEZ(2)=10HIMPEDANCE(                                           PLOT   39
              YTITLEZ(3)=10HZ)                                                   PLOT   40
              YTITVOC(1)=10HOPEN CIRCU                                           PLOT   41
              YTITVOC(2)=10HIT VOLTAGE                                           PLOT   42
              YTITVOC(3)=10H(VOC)                                                PLOT   43
              YTITLEI(1)=5H                                                      PLOT   44
              YTITLEI(2)=10HCURRENT(IP                                           PLOT   45
              YTITLEI(3)=10H)                                                    PLOT   46
              LEGEN(1)=10HLEAST SQUA                                             PLOT   47
              LEGEN(2)=10HRES FIT TO                                             PLOT   48
              LEGEN(3)=10H DATA                                                  PLOT   49
              BLANK(1)=10HDATA PAIRS                                             PLOT   50
              BLANK(2)=10H                                                       PLOT   51
              BLANK(3)=10H                                                       PLOT   52
              IF(J.EQ.2)  GO TO 60                                               PLOT   53
              IF(J.EQ.3)  GO TO 90                                               PLOT   54
           20 GO TO (30,40,30),FLAG                                              PLOT   55
           30 RTITLEA(1)=10H  DEVICE:                                            PLOT   56
              RTITLEA(2)=DEV                                                     PLOT   57
              RTITLEA(3)=10H   REVERSE                                           PLOT   58
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SUBROUTINE PLOTT     74/74   OPT=1                  FTN 4.5+414      06/01/76  14.04.49       PAGE    2

          RTITLEA(4)=10H FAILURE                                   PLOT      59
          RTITLEA(5)=10H   FIT TO                                  PLOT      60
          RTITLEA(6)=10HP=A*T**(-1                                 PLOT      61
          RTITLEA(7)=10H)                                          PLOT      62
          RTITLEB(1)=10H  DEVICE:                                  PLOT      63
          RTITLEB(2)=DEV                                           PLOT      64
          RTITLEB(3)=10H   REVERSE                                 PLOT      65
          RTITLEB(4)=10H FAILURE                                   PLOT      66
          RTITLEB(5)=10H   FIT TO                                  PLOT      67
          RTITLEB(6)=10HP=B*T**(-.                                 PLOT      68
          RTITLEB(7)=10H5)                                         PLOT      69
          IF(ISEM.EQ.0)  GO TO 33                                  PLOT      70
          CALL CHANGE(KNUM,XTITLE,YTITLE,TDRF,PRF)                 PLOT      71
     33   CALL PWRITE(2,RTITLEA,XTITLE,YTITLE,BLANK,LEGEN,KNUM,TDRF,PRF,   PLOT      72
         1T,P2)                                                    PLOT      73
          CALL PWRITE(2,RTITLEB,XTITLE,YTITLE,BLANK,LEGEN,KNUM,TDRF,PRF,   PLOT      74
         1T,P3)                                                    PLOT      75
          IF(ISEM.EQ.1)  GO TO 35                                  PLOT      76
          CALL PWRITE(1,ETITLER,XTITLE,YTITLEE,BLANK,BLANK,KNUM,TDRF,ERF,  PLOT      77
         10.,0.)                                                   PLOT      78
     35   IF(FLAG.EQ.1)  GO TO 50                                  PLOT      79
     40   RTITLAB(1)=10H  DEVICE:                                  PLOT      80
          RTITLAB(2)=DEV                                           PLOT      81
          RTITLAB(3)=10H   REVERSE                                 PLOT      82
          RTITLAB(4)=10H FAILURE                                   PLOT      83
          RTITLAB(5)=10H   FIT TO                                  PLOT      84
          RTITLAB(6)=10HP=A*T**(-1                                 PLOT      85
          RTITLAB(7)=10H)+B*T**(-.                                 PLOT      86
          RTITLAB(8)=10H5)                                         PLOT      87
          IF(ISEM.EQ.0)  GO TO 43                                  PLOT      88
          CALL CHANGE(KNUM,XTITLE,YTITLE,TDRF,PRF)                 PLOT      89
     43   CALL PWRITE(2,RTITLAB,XTITLE,YTITLE,BLANK,LEGEN,KNUM,TDRF,PRF,   PLOT      90
         1T,P1)                                                    PLOT      91
          IF(ISEM.EQ.1)  GO TO 50                                  PLOT      92
          IF(FLAG.EQ.3)  GO TO 50                                  PLOT      93
          CALL PWRITE(1,ETITLER,XTITLE,YTITLEE,BLANK,BLANK,KNUM,TDRF,ERF,  PLOT      94
         10.,0.)                                                   PLOT      95
     50   CONTINUE                                                 PLOT      96
          IF(J.EQ.1)  RETURN                                       PLOT      97
     60   IF(JNUM.EQ.0)  GO TO 130                                 PLOT      98
          GO TO (70,80,70),FLAG                                    PLOT      99
     70   FTITLEA(1)=10H  DEVICE:                                  PLOT     100
          FTITLEA(2)=DEV                                           PLOT     101
          FTITLEA(3)=10H   FORWARD                                 PLOT     102
          FTITLEA(4)=10H FAILURE                                   PLOT     103
          FTITLEA(5)=10H   FIT TO                                  PLOT     104
          FTITLEA(6)=10HP=A*T**(-1                                 PLOT     105
          FTITLEA(7)=10H)                                          PLOT     106
          FTITLEB(1)=10H  DEVICE:                                  PLOT     107
          FTITLEB(2)=DEV                                           PLOT     108
          FTITLEB(3)=10H   FORWARD                                 PLOT     109
          FTITLEB(4)=10H FAILURE                                   PLOT     110
          FTITLEB(5)=10H   FIT TO                                  PLOT     111
          FTITLEB(6)=10HP=B*T**(-.                                 PLOT     112
          FTITLEB(7)=10H5)                                         PLOT     113
          IF(ISEM.EQ.0)  GO TO 73                                  PLOT     114
          CALL CHANGE(JNUM,XTITLE,YTITLE,TDFF,PFF)                 PLOT     115
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   73 CALL PWRITE(2,FTITLEA,XTITLE,YTITLE,BLANK,LEGEN,JNUM,TDFF,PFF,      PLOT   116
     1T,P2)                                                               PLOT   117
      CALL PWRITE(2,FTITLEB,XTITLE,YTITLE,BLANK,LEGEN,JNUM,TDFF,PFF,      PLOT   118
     1T,P3)                                                               PLOT   119
      IF(ISEM.EC.1)  GO TO 75                                             PLOT   120
      CALL PWRITE(1,FTITLEF,XTITLE,YTITLEE,BLANK,BLANK,JNUM,TDFF,EFF,     PLOT   121
     10.,0.)                                                              PLOT   122
   75 IF(FLAG.EQ.1)  GO TO 90                                             PLOT   123
   80 FTITLAB(1)=10H  DEVICE:                                             PLOT   124
      FTITLAB(2)=DEV                                                      PLOT   125
      FTITLAB(3)=10H   FORWARD                                            PLOT   126
      FTITLAB(4)=10H FAILURE                                              PLOT   127
      FTITLAB(5)=10H   FIT TO                                             PLOT   128
      FTITLAB(6)=10HP=A*T**(-1                                            PLOT   129
      FTITLAB(7)=10H)+B*T**(-.                                            PLOT   130
      FTITLAB(8)=10H5)                                                    PLOT   131
      IF(ISEM.EQ.0)  GO TO 83                                             PLOT   132
      CALL CHANGE(JNUM,XTITLE,YTITLE,TDFF,PFF)                            PLOT   133
   83 CALL PWRITE(2,FTITLAB,XTITLE,YTITLE,BLANK,LEGEN,JNUM,TOFF,PFF,      PLOT   134
     1T,P1)                                                               PLOT   135
      IF(ISEM.EQ.1)  GO TO 90                                             PLOT   136
      IF(FLAG.EQ.3)  GO TO 90                                             PLOT   137
      CALL PWRITE(1,ETITLEF,XTITLE,YTITLEE,BLANK,BLANK,JNUM,TDFF,EFF,     PLOT   138
     10.,0.)                                                              PLOT   139
   90 CONTINUE                                                            PLOT   140
      IF(JNUM.EQ.0)  GO TO 130                                            PLOT   141
      IF(J.EQ.2)  RETURN                                                  PLOT   142
  100 GO TO (110,120,110,110),IPRAM                                       PLOT   143
  110 CALL PWRITE(1,ETITLER,XTITLE,YTITLEZ,BLANK,BLANK,KNUM,TDRF,ZRF,     PLOT   144
     10.,0.)                                                              PLOT   145
      CALL PWRITE(1,ETITLER,XTITLE,YTITVOC,BLANK,BLANK,KNUM,TDRF,VOCRF,   PLOT   146
     10.,0.)                                                              PLOT   147
      CALL PWRITE(1,ETITLER,XTITLEP,YTITVOC,BLANK,BLANK,KNUM,TDOCRF,      PLOT   148
     1VOCRF,0.,0.)                                                        PLOT   149
      CALL PWRITE(1,ETITLER,XTITLE,YTITLEI,BLANK,BLANK,KNUM,TDRF,IPRF,    PLOT   150
     10.,0.)                                                              PLOT   151
      IF(IPRAM.EQ.1)  RETURN                                              PLOT   152
  120 CALL PWRITE(1,ETITLEF,XTITLE,YTITLEZ,BLANK,BLANK,JNUM,TDFF,ZFF,     PLOT   153
     10.,0.)                                                              PLOT   154
      CALL PWRITE(1,ETITLEF,XTITLE,YTITVOC,BLANK,BLANK,JNUM,TDFF,VOCFF,   PLOT   155
     10.,0.)                                                              PLOT   156
      CALL PWRITE(1,ETITLEF,XTITLEP,YTITVOC,BLANK,BLANK,JNUM,TDOCFF,      PLOT   157
     1VOCFF,0.,0.)                                                        PLOT   158
      CALL PWRITE(1,ETITLEF,XTITLE,YTITLEI,BLANK,BLANK,JNUM,TDFF,IPFF,    PLOT   159
     10.,0.)                                                              PLOT   160
      RETURN                                                              PLOT   161
  130 STOP                                                                PLOT   162
      END                                                                 PLOT   163
```

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CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

   54      I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   98      I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
```

APPENDIX C

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   SUBROUTINE PLOTT       74/74   OPT=1                              FTN 4.5+414        06/01/76  14.04.49        PAGE    4

   SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS       DEF LINE      REFERENCES
    3  PLOTT           1             96        141        151        160

VARIABLES       SN  TYPE                RELOCATION
 1036  BLANK        REAL         ARRAY                  REFS        13        71        73      2*76        89      2*93       115
                                                         117     2*120       133     2*137     2*143     2*145     2*147     2*149
                                                       2*152     2*154     2*156     2*158   DEFINED        15        49        50
                                                          51
    3  DEV          REAL                      A         REFS         4        28        34        56        63        80       100
                                                         107       124
 2260  EFF          REAL         ARRAY        C         REFS         7       120       137
 2260  ERF          REAL         ARRAY        B         REFS         5        76        93
  766  ETITLEF      REAL         ARRAY                  REFS        11       120       137       152       154       156       158
                                                     DEFINED        15        33        34        35        36
  726  ETITLER      REAL         ARRAY                  REFS        11        76        93       143       145       147       149
                                                     DEFINED        15        27        28        29        30
    1  FLAG         INTEGER                   A         REFS         2         4        54        78        92        98       122
                                                         136
  776  FTITLAB      REAL         ARRAY                  REFS        11       133   DEFINED        15       123       124       125
                                                         126       127       128       129       130
  746  FTITLEA      REAL         ARRAY                  REFS        11       115   DEFINED        15        99       100       101
                                                         102       103       104       105
  756  FTITLEB      REAL         ARRAY                  REFS        11       117   DEFINED        15       106       107       108
                                                         109       110       111       112
    0  IND          INTEGER                   A         REFS         4
  705  IP         * REAL        *UNDEF                  REFS         3
 7020  IPFF         REAL         ARRAY        C         REFS         3         7       158
    0  IPLOT        INTEGER                   F         REFS        10
    2  IPRAM        INTEGER                   A         REFS         4       142       151
 7020  IPRF         REAL         ARRAY        B         REFS         3         5       149
    1  ISEM         INTEGER                   F         REFS        10        69        75        87        91       113       119
                                                         131       135
    2  ITYPE        INTEGER                   F         REFS        10
    0  J            INTEGER                    F.P.     REFS        52        53        96       141   DEFINED         1
    0  JNUM         INTEGER                    F.P.     REFS        97       114       115       117       120       132       133
                                                         137       140       152       154       156       158
                                                     DEFINED         1
    0  KNUM         INTEGER                    F.P.     REFS        70        71        73        76        88        69        93
                                                         143       145       147       149   DEFINED         1
 1033  LEGEN        INTEGER      ARRAY                  REFS        13        71        73        89       115       117       133
                                                     DEFINED        15        46        47        48
    0  PFF          REAL         ARRAY        C         REFS         7       114       115       117       132       133
 1130  PP           REAL         ARRAY        D         REFS         9
    0  PRF          REAL         ARRAY        B         REFS         5        70        71        73        88        89
10150  P1           REAL         ARRAY        B         REFS         5        89       133
11300  P2           REAL         ARRAY        B         REFS         5        71       115
12430  P3           REAL         ARRAY        B         REFS         5        73       117
  736  RTITLAB      REAL         ARRAY                  REFS        11        89   DEFINED        15        79        80        81
                                                          82        83        84        85        86
  706  RTITLEA      PEAL         ARRAY                  REFS        11        71   DEFINED        15        55        56        57
                                                          58        59        60        61
  716  RTITLEB      REAL         ARRAY                  REFS        11        73   DEFINED        15        62        63        64
                                                          65        66        67        68
    0  T            REAL         ARRAY        D         REFS         9        71        73        89       115       117       133
 1130  TDFF         REAL         ARRAY        C         REFS         7       114       115       117       120       132       133
```

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        SUBROUTINE PLOTT       74/74    OPT=1                          FTN 4.5+414        06/01/76  14.04.49        PAGE     5

   VARIABLES      SN  TYPE               RELOCATION
                                                    137     152     154     158
  3410  TDOCFF      REAL        ARRAY   C          REFS       7     156
  3410  TDOCRF      REAL        ARRAY   B          REFS       5     147
  1130  TDRF        REAL        ARRAY   B          REFS       5      70      71      73      76      88      89
                                                     93     143     145     149
  5670  VOCFF       REAL        ARRAY   C          REFS       7     154     156
  5670  VOCRF       REAL        ARRAY   B          REFS       5     145     147
  1006  XTITLE      REAL        ARRAY              REFS      13      70      71      73      76      88      89
                                                     93     114     115     117     120     132     133     137
                                                    143     145     149     152     154     158
                                                DEFINED      15      20      21      22
  1017  XTITLEP     REAL        ARRAY              REFS      13     147     156  DEFINED      15      31      32
  1011  YTITLE      REAL        ARRAY              REFS      13      70      71      73      88      89     114
                                                    115     117     132     133  DEFINED      15      23      24
  1014  YTITLEE     REAL        ARRAY              REFS      13      76      93     120     137
                                                DEFINED      15      25      26
  1030  YTITLEI     REAL        ARRAY              REFS      13     149     158  DEFINED      15      43      44
                                                     45
  1022  YTITLEZ     REAL        ARRAY              REFS      13     143     152  DEFINED      15      37      38
                                                     39
  1025  YTITVDC     REAL        ARRAY              REFS      13     145     147     154     156
                                                DEFINED      15      40      41      42
  4540  ZFF         REAL        ARRAY   C          REFS       7     152
  4540  ZRF         REAL        ARRAY   B          REFS       5     143

  EXTERNALS            TYPE   ARGS      REFERENCES
        CHANGE                  5           70      88     114     132
        PWRITE                 11           71      73      76      89      93     115     117     120     133
                                           137     143     145     147     149     152     154     156     158

  STATEMENT LABELS               DEF LINE   REFERENCES
      0  20          INACTIVE       54
     66  30                         55       2*54
    111  33                         71         69
    124  35                         78         75
    126  40                         79         54
    145  43                         89         87
    157  50                         95         78      91      92
    161  60                         97         52
    172  70                         99       2*98
    215  73                        115        113
    230  75                        122        119
    232  80                        123         98
    251  83                        133        131
    263  90                        139         53     122     135     136
      0 100          INACTIVE      142
    277 110                        143      3*142
    315 120                        152        142
    332 130                        161         97     140

  COMMON BLOCKS     LENGTH     MEMBERS - BIAS NAME(LENGTH)
     A                 4               0 IND     (1)             1 FLAG     (1)             2 IPRAM    (1)
                                       3 DEV     (1)
     B              6000               0 PRF     (600)         600 TDRF     (600)        1200 ERF      (600)
                                    1800 TDOCRF  (600)        2400 ZRF      (600)        3000 VOCRF    (600)
                                    3600 IPRF    (600)        4200 P1       (600)        4800 P2       (600)
                                    5400 P3      (600)
```

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      SUBROUTINE PLOTT       74/74   OPT=1                          FTN 4.5+414       06/01/76  14.04.49        PAGE     6

COMMON BLOCKS    LENGTH       MEMBERS - BIAS NAME(LENGTH)
    C              4200                0 PFF     (600)           600 TDFF    (600)           1200 EFF     (600)
                                    1800 TDDCFF  (600)          2400 ZFF     (600)           3000 VDCFF   (600)
                                    3600 IPFF    (600)
    D              1200                0 T       (600)           600 PP      (600)
    F                 3                0 IPLOT   (1)               1 ISEM    (1)                2 ITYPE   (1)

STATISTICS
  PROGRAM LENGTH               1041B     545
  CM LABELED COMMON LENGTH    26217B   11407
```

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SUBROUTINE ALSQAR      74/74    OPT=1                          FTN 4.5+414        06/01/76  14.04.49        PAGE      1

                    SUBROUTINE ALSQAR(N,A)                                            ALSQAR      2
                    REAL IPRF                                                         ALSQAR      3
                    COMMON/B/PRF(600),TDRF(600),ERF(600),TDOCRF(600),ZRF(600),        ALSQAR      4
                   1          VDCRF(600),IPRF(600),P1(600),P2(600),P3(600)            ALSQAR      5
                    COMMON/D/T(600),PP(600)                                           ALSQAR      6
                    SUMTC=0.                                                          ALSQAR      7
                    SUMCP=0.                                                          ALSQAR      8
                    DO 10 I=1,N                                                       ALSQAR      9
                    SUMTC=SUMTC+ALOG10(T(I))                                          ALSQAR     10
                    SUMCP=SUMCP+ALOG10(PP(I))                                         ALSQAR     11
                 10 CONTINUE                                                          ALSQAR     12
                    ARG=(SUMTC+SUMCP)/N                                               ALSQAR     13
                    A=10.**ARG                                                        ALSQAR     14
                    DO 20 I=1,N                                                       ALSQAR     15
                 20 P2(I)=A*T(I)**(-1)                                                ALSQAR     16
                    RETURN                                                            ALSQAR     17
                    END                                                               ALSQAR     18


     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE      REFERENCES
    3 ALSQAR         1            16

VARIABLES     SN  TYPE              RELOCATION
    0  A          REAL                  F.P.        REFS       15   DEFINED        1        13
   53  ARG        REAL                              REFS       13   DEFINED       12
 2260  ERF        REAL        ARRAY    B            REFS        3
   52  I          INTEGER                           REFS        9       10      2*15   DEFINED        8        14
 7020  IPRF       REAL        ARRAY    B            REFS        2        3
    0  N          INTEGER               F.P.        REFS        8       12        14   DEFINED        1
 1130  PP         REAL        ARRAY    D            REFS        5       10
    0  PRF        REAL        ARRAY    B            REFS        3
10150  P1         REAL        ARRAY    B            REFS        3
11300  P2         REAL        ARRAY    B            REFS        3   DEFINED       15
12430  P3         REAL        ARRAY    B            REFS        3
   51  SUMCP      REAL                              REFS       10       12   DEFINED        7        10
   50  SUMTC      REAL                              REFS        9       12   DEFINED        6         9
    0  T          REAL        ARRAY    D            REFS        5        9        15
 3410  TDOCRF     REAL        ARRAY    B            REFS        3
 1130  TDRF       REAL        ARRAY    B            REFS        3
 5670  VDCRF      REAL        ARRAY    B            REFS        3
 4540  ZRF        REAL        ARRAY    B            REFS        3

EXTERNALS          TYPE    ARGS         REFERENCES
      ALOG10       REAL    1 LIBRARY        9          10

STATEMENT LABELS             DEF LINE    REFERENCES
    0  10                       11          8
    0  20                       15         14

LOOPS  LABEL     INDEX      FROM-TO     LENGTH     PROPERTIES
   20  10      * I            8 11        11B                EXT REFS
   40  20      * I           14 15         6B                EXT REFS
```

```
      SUBROUTINE ALSQAR      74/74    OPT=1                      FTN 4.5+414        06/01/76  14.04.49        PAGE     2

COMMON BLOCKS    LENGTH      MEMBERS - BIAS NAME(LENGTH)
      B          6000                 0 PRF      (600)            600 TDRF     (600)            1200 ERF      (600)
                                   1800 TDDCRF  (600)            2400 ZRF      (600)            3000 VDCRF    (600)
                                   3600 IPRF     (600)            4200 P1       (600)            4800 P2       (600)
                                   5400 P3       (600)
      D          1200                 0 T        (600)            600 PP       (600)

STATISTICS
  PROGRAM LENGTH                   61B       49
  CM LABELED COMMON LENGTH      16040B     7200
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SUBROUTINE BLSQAR      74/74    OPT=1                              FTN 4.5+414        06/01/76  14.04.49       PAGE     1

    1              SUBROUTINE BLSQAR(N,B)                                             BLSQAR      2
                   REAL IPRF                                                          BLSQAR      3
                   COMMON/B/PRF(600),TDRF(600),ERF(600),TDDCRF(600),ZRF(600),         BLSQAR      4
                 1           VOCRF(600),IPRF(600),P1(600),P2(600),P3(600)             BLSQAR      5
    5              COMMON/D/T(600),PP(600)                                            BLSQAR      6
                   SUMTD=0.                                                           BLSQAR      7
                   SUMDP=0.                                                           BLSQAR      8
                   DO 10 I=1,N                                                        BLSQAR      9
                   SUMTD=SUMTD+ALOG10(T(I))                                           BLSQAR     10
   10              SUMDP=SUMDP+ALOG10(PP(I))                                          BLSQAR     11
                10 CONTINUE                                                           BLSQAR     12
                   ARG=(SUMDP+.5*SUMTD)/N                                             BLSQAR     13
                   B=10.**ARG                                                         BLSQAR     14
                   DO 20 I=1,N                                                        BLSQAR     15
   15           20 P3(I)=B*T(I)**(-.5)                                                BLSQAR     16
                   RETURN                                                             BLSQAR     17
                   END                                                                BLSQAR     18


      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    3 BLSQAR           1            16

VARIABLES      SN  TYPE             RELOCATION
   55 ARG          REAL                              REFS      13  DEFINED      12
    0 B            REAL                 F.P.         REFS      15  DEFINED       1        13
 2260 ERF          REAL       ARRAY    B             REFS       3
   54 I            INTEGER                           REFS       9       10    2*15  DEFINED        8        14
 7020 IPRF         REAL       ARRAY    B             REFS       2        3
    0 N            INTEGER              F.P.         REFS       8       12      14  DEFINED        1
 1130 PP           REAL       ARRAY    D             REFS       5       10
    0 PRF          REAL       ARRAY    B             REFS       3
10150 P1           REAL       ARRAY    B             REFS       3
11300 P2           REAL       ARRAY    B             REFS       3
12430 P3           REAL       ARRAY    B             REFS       3  DEFINED      15
   53 SUMDP        REAL                              REFS      10       12  DEFINED       7        10
   52 SUMTD        REAL                              REFS       9       12  DEFINED       6         9
    0 T            REAL       ARRAY    D             REFS       5        9      15
 3410 TDDCRF       REAL       ARRAY    B             REFS       3
 1130 TDRF         REAL       ARRAY    B             REFS       3
 5670 VOCRF        REAL       ARRAY    B             REFS       3
 4540 ZRF          REAL       ARRAY    B             REFS       3

EXTERNALS          TYPE    ARGS          REFERENCES
      ALOG10       REAL       1 LIBRARY       9        10

STATEMENT LABELS               DEF LINE    REFERENCES
    0 10                          11           8
    0 20                          15          14

LOOPS  LABEL      INDEX      FROM-TO    LENGTH     PROPERTIES
   20  10       * I           8 11       11B                EXT REFS
   40  20.      * I          14 15        6B                EXT REFS
```

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      SUBROUTINE BLSQAR      74/74   OPT=1                          FTN 4.5+414       06/01/76  14.04.49        PAGE      2

COMMON BLOCKS    LENGTH      MEMBERS - BIAS NAME(LENGTH)
      B           6000                 0 PRF      (600)         600 TDRF    (600)           1200 ERF     (600)
                                    1800 TDDCRF (600)          2400 ZRF     (600)           3000 VDCRF   (600)
                                    3600 IPRF     (600)        4200 P1      (600)           4800 P2      (600)
                                    5400 P3       (600)
      D           1200                 0 T        (600)         600 PP      (600)

STATISTICS
  PROGRAM LENGTH                  63B        51
  CM LABELED COMMON LENGTH     16040B      7200
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SUBROUTINE ABLSQAR    74/74   OPT=1                    FTN 4.5+414        06/01/76  14.04.49        PAGE    1

          SUBROUTINE ABLSQAR(N,AI,BI,AE,BE,IT)
          REAL IPRF                                                          ABLSQAR    2
          COMMON/A/IND,FLAG,IPRAM,DEV                                        ABLSQAR    3
          COMMON/B/PRF(600),TDRF(600),ERF(600),TDDCRF(600),ZRF(600),         ABLSQAR    4
         1         VOCRF(600),IPRF(600),P1(600),P2(600),P3(600)              ABLSQAR    5
          COMMON/D/T(600),PP(600)                                            ABLSQAR    6
          COMMON/E/GAUS(3),S                                                 ABLSQAR    7
          DIMENSION A(500),B(500)                                            ABLSQAR    8
          I=1                                                                ABLSQAR    9
          J=1                                                                ABLSQAR   10
          EPS=1.E-4                                                          ABLSQAR   11
          A(I)=AI                                                            ABLSQAR   12
          B(I)=BI                                                            ABLSQAR   13
       10 L=0                                                                ABLSQAR   14
          SI=SAB(N,A(I),B(I))                                                ABLSQAR   15
          AI=A(I)/(2.**J)                                                    ABLSQAR   16
          A(I+1)=A(I)-AI                                                     ABLSQAR   17
          IF(SAB(N,A(I+1),B(I)).LT.SI)  GO TO 20                             ABLSQAR   18
          A(I+1)=A(I)+AI                                                     ABLSQAR   19
          IF(SAB(N,A(I+1),B(I)).LT.SI)  GO TO 20                             ABLSQAR   20
          A(I+1)=A(I)                                                        ABLSQAR   21
          GO TO 30                                                           ABLSQAR   22
       20 L=1                                                                ABLSQAR   23
       30 BI=B(I)/(2.**J)                                                    ABLSQAR   24
          B(I+1)=B(I)-BI                                                     ABLSQAR   25
          IF(SAB(N,A(I+1),B(I+1)).LT.SI)  GO TO 40                           ABLSQAR   26
          B(I+1)=B(I)+BI                                                     ABLSQAR   27
          IF(SAB(N,A(I+1),B(I+1)).LT.SI)  GO TO 40                           ABLSQAR   28
          B(I+1)=B(I)                                                        ABLSQAR   29
          GO TO 50                                                           ABLSQAR   30
       40 L=1                                                                ABLSQAR   31
       50 IF(L.EQ.1)  GO TO 60                                               ABLSQAR   32
          I=I+1                                                              ABLSQAR   33
          IF(J.GT.20)  GO TO 90                                              ABLSQAR   34
          J=J+1                                                              ABLSQAR   35
          GO TO 10                                                           ABLSQAR   36
       60 S=SAB(N,A(I+1),B(I+1))                                             ABLSQAR   37
          ERR=ABS(S-SI)                                                      ABLSQAR   38
          IF(ERR.LT.EPS)  GO TO 70                                           ABLSQAR   39
          I=I+1                                                              ABLSQAR   40
          GO TO 10                                                           ABLSQAR   41
       70 AE=A(I+1)                                                          ABLSQAR   42
          BE=B(I+1)                                                          ABLSQAR   43
          IT=I                                                               ABLSQAR   44
          DO 80 I=1,N                                                        ABLSQAR   45
       80 P1(I)=AE*T(I)**(-1)+BE*T(I)**(-.5)                                 ABLSQAR   46
          GO TO 110                                                          ABLSQAR   47
       90 WRITE(6,100)                                                       ABLSQAR   48
      100 FORMAT(/,/,/,1X,41HNUMBER OF ITERATIONS FOR 2**J EXCEED J=20)      ABLSQAR   49
      110 RETURN                                                             ABLSQAR   50
          END                                                                ABLSQAR   51
                                                                             ABLSQAR   52
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        SUBROUTINE ABLSQAR    74/74   OPT=1                          FTN 4.5+414       06/01/76  14.04.49       PAGE     2

        SYMBOLIC REFERENCE MAP (R=3)

    ENTRY POINTS      DEF LINE      REFERENCES
        3  ABLSQAR        1           50

    VARIABLES      SN  TYPE              RELOCATION
      213  A           REAL       ARRAY               REFS        8        15        16        17        18        19        20
                                                        21       26        28        37        42   DEFINED        12        17
                                                        19       21
        0  AF          REAL              F.P.         REFS       46   DEFINED         1        42
        0  AI          REAL              F.P.         REFS       12   DEFINED         1
      210  A1          REAL                           REFS       17        19   DEFINED        16
     1177  B           REAL       ARRAY               REFS        8        15        18        20        24        25        26
                                                        27       28        29        37        43   DEFINED        13        25
                                                        27       29
        0  BE          REAL              F.P.         REFS       46   DEFINED         1        43
        0  BI          REAL              F.P.         REFS       13   DEFINED         1
      211  B1          REAL                           REFS       25        27   DEFINED        24
        3  DEV         REAL             A             REFS        3
      205  EPS         REAL                           REFS       39   DEFINED        11
     2260  ERF         REAL       ARRAY  B            REFS        4
      212  ERR         REAL                           REFS       39   DEFINED        38
        1  FLAG        REAL             A             REFS        3
        0  GAUS        REAL       ARRAY  E            REFS        7
      203  I           INTEGER                        REFS       12        13      2*15        16      2*17      2*18      2*19
                                                      2*20     2*21        24      2*25      2*26      2*27      2*28      2*29
                                                        33     2*37        40        42        43        44      3*46
                                                   DEFINED        9        33        40        45
        0  IND         INTEGER          A             REFS        3
        2  IPRAM       INTEGER          A             REFS        3
     7020  IPRF        REAL       ARRAY  B            REFS        2         4
        0  IT          INTEGER           F.P.      DEFINED        1        44
      204  J           INTEGER                        REFS       16        24        34        35   DEFINED        10        35
      206  L           INTEGER                        REFS       32   DEFINED        14        23        31
        0  N           INTEGER           F.P.         REFS       15        18        20        26        28        37        45
                                                   DEFINED        1
     1130  PP          REAL       ARRAY  D            REFS        6
        0  PRF         REAL       ARRAY  B            REFS        4
    10150  P1          REAL       ARRAY  B            REFS        4   DEFINED        46
    11300  P2          REAL       ARRAY  B            REFS        4
    12430  P3          REAL       ARRAY  B            REFS        4
        3  S           REAL             E             REFS        7        38   DEFINED        37
      207  SI          REAL                           REFS       18        20        26        28        38
                                                   DEFINED       15
        0  T           REAL       ARRAY  D            REFS        6      2*46
     3410  TDDCRF      REAL       ARRAY  B            REFS        4
     1130  TDRF        REAL       ARRAY  B            REFS        4
     5670  VDCRF       REAL       ARRAY  B            REFS        4
     4540  ZRF         REAL       ARRAY  B            REFS        4

    FILE NAMES         MODE
          TAPF6        FMT                 WRITES       48

    EXTERNALS          TYPE    ARGS        REFERENCES
          SAB          REAL      3                 15        18        20        26        28        37
```

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         SUBROUTINE ABLSQAR    74/74    OPT=1                          FTN 4.5+414      06/01/76  14.04.49      PAGE     3

INLINE FUNCTIONS   TYPE    ARGS         DEF LINE  REFERENCES
         ABS        REAL      1  INTRIN                38

STATEMENT LABELS                DEF LINE   REFERENCES
    23  10                          14         36        41
    60  20                          23         18        20
    61  30                          24         22
   110  40                          31         26        28
   111  50                          32         30
   117  60                          37         32
   133  70                          42         39
     0  80                          46         45
   154  90                          48         34
   170  100      FMT                49         48
   156  110                         50         47

LOOPS  LABEL    INDEX      FROM-TO     LENGTH     PROPERTIES
  141  80     * I           45 46        13B                 EXT REFS

COMMON BLOCKS   LENGTH     MEMBERS - BIAS NAME(LENGTH)
         A           4               0 IND     (1)                1 FLAG    (1)               2 IPRAM  (1)
                                     3 DEV     (1)
         B        6000               0 PRF     (600)            600 TDRF    (600)          1200 ERF     (600)
                                  1800 TDOCRF  (600)           2400 ZRF     (600)          3000 VOCRF   (600)
                                  3600 IPRF    (600)           4200 P1      (600)          4800 P2      (600)
                                  5400 P3      (600)
         D        1200               0 T       (600)            600 PP      (600)
         E           4               0 GAUS    (3)                3 S       (1)

STATISTICS
  PROGRAM LENGTH                   2177B      1151
  CM LABELED COMMON LENGTH        16050B      7208
```

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SUBROUTINE PWRITE      74/74    OPT=1                          FTN 4.5+414        06/01/76  14.04.49         PAGE      1

 1                  SUBROUTINE PWRITE(K,T,XT,YT,GLD,GLL,N,X,Y,XX,YY)                    PWRITE     2
                    COMMON/F/IPLOT,ISEM,ITYPE                                           PWRITE     3
                    DIMENSION X(600),Y(600),XX(600),YY(600)                             PWRITE     4
                    DIMENSION T(8),XT(3),YT(3),GLD(3),GLL(3)                            PWRITE     5
 5                  IF(ITYPE.EQ.1)  GO TO 10                                            PWRITE     6
                    CALL SELPLOT(IPLOT)                                                 PWRITE     7
                    CALL TALGRAF(K,0.,0.,0.,0.,0.,0.,T,XT,YT)                           PWRITE     8
                    CALL TALDATA(N,X,Y,1,1,2,GLD)                                       PWRITE     9
                    IF(K.EQ.1)  RETURN                                                  PWRITE    10
10                  CALL TALDATA(N,XX,YY,1,1,1,GLL)                                     PWRITE    11
                    RETURN                                                              PWRITE    12
               10   CONTINUE                                                            PWRITE    13
                    CALL DRAW4(1,7,3,3,3,8,XT,YT,GLL,T)                                 PWRITE    14
                    CALL DRAW4(2,7,2,N,-2,10,X,Y,0.,0.)                                 PWRITE    15
15                  IF(K.EQ.1)  GO TO 20                                                PWRITE    16
                    CALL DRAW4(2,7,2,N,0,10,XX,YY,0.,0.)                                PWRITE    17
               20   CALL DRAW4(3,7,2,0,2,N,XX,YY,2.,0.)                                 PWRITE    18
                    RETURN                                                              PWRITE    19
                    END                                                                 PWRITE    20


      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE       REFERENCES
   3  PWRITE          1             9          11          18

VARIABLES       SN  TYPE             RELOCATION
    0  GLD          REAL        ARRAY     F.P.         REFS          4         8      DEFINED      1
    0  GLL          REAL        ARRAY     F.P.         REFS          4        10         13    DEFINED       1
    0  IPLOT        INTEGER              F             REFS          2         6
    1  ISEM         INTEGER              F             REFS          2
    2  ITYPE        INTEGER              F             REFS          2         5
    0  K            INTEGER               F.P.         REFS          7         9         15    DEFINED       1
    0  N            INTEGER               F.P.         REFS          8        10         14       16        17
                                                    DEFINED          1
    0  T            REAL        ARRAY     F.P.         REFS          4         7         13    DEFINED       1
    0  X            REAL        ARRAY     F.P.         REFS          3         8         14    DEFINED       1
    0  XT           REAL        ARRAY     F.P.         REFS          4         7         13    DEFINED       1
    0  XX           REAL        ARRAY     F.P.         REFS          3        10         16       17    DEFINED       1
    0  Y            REAL        ARRAY     F.P.         REFS          3         8         14    DEFINED       1
    0  YT           REAL        ARRAY     F.P.         REFS          4         7         13    DEFINED       1
    0  YY           REAL        ARRAY     F.P.         REFS          3        10         16       17    DEFINED       1

EXTERNALS             TYPE    ARGS          REFERENCES
           DRAW4               10               13         14        16        17
           SELPLOT              1                6
           TALDATA              7                8         10
           TALGRAF             10                7

STATEMENT LABELS               DEF LINE     REFERENCES
   41  10                         12            5
   67  20                         17           15
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```
      SUBROUTINE PWRITE     74/74    OPT=1                    FTN 4.5+414       06/01/76  14.04.49        PAGE     2

COMMON BLOCKS   LENGTH      MEMBERS - BIAS NAME(LENGTH)
      F            3                0 IPLOT  (1)             1 ISEM   (1)              2 ITYPE  (1)

STATISTICS
  PROGRAM LENGTH                  220B      144
  CM LABELED COMMON LENGTH         3B        3
```

```
SUBROUTINE SORT        74/74    OPT=1                    FTN 4.5+414        06/01/76  14.04.49        PAGE    1

                SUBROUTINE SORT(N)
                COMMON/D/T(600),PP(600)
                DIMENSION E(600),H(600)
                I=1
                J=0
             10 TDMIN=1.E300
                DO 20 L=1,N
                TDMIN=AMIN1(TDMIN,T(L))
                IF(TDMIN.EQ.T(L)) J=L
             20 CONTINUE
                IF(TDMIN.GT.1.E50)  GO TO 40
                E(I)=PP(J)
                H(I)=TDMIN
                I=I+1
                T(J)=1.E51
                GO TO 10
             40 CONTINUE
                DO 50 L=1,N
                PP(L)=E(L)
                T(L)=H(L)
             50 CONTINUE
                RETURN
                END
```

```
      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE     REFERENCES
    3  SORT          1           22

VARIABLES      SN  TYPE            RELOCATION
   51  E           REAL        ARRAY                REFS     3      19   DEFINED     12
 1201  H           REAL        ARRAY                REFS     3      20   DEFINED     13
   45  I           INTEGER                          REFS    12      13        14   DEFINED        4        14
   46  J           INTEGER                          REFS    12      15   DEFINED      5        9
   50  L           INTEGER                          REFS     8     2*9      2*19     2*20   DEFINED        7        18
    0  N           INTEGER               F.P.       REFS     7      18   DEFINED      1
 1130  PP          REAL        ARRAY    D           REFS     2      12   DEFINED     19
    0  T           REAL        ARRAY    D           REFS     2       8         9   DEFINED       15        20
   47  TDMIN       REAL                             REFS     8       9        11       13   DEFINED        6         8

INLINE FUNCTIONS    TYPE    ARGS        DEF LINE   REFERENCES
       AMIN1        REAL      0  INTRIN                 8

STATEMENT LABELS                DEF LINE    REFERENCES
    7  10                           6           16
    0  20                          10            7
   32  40                          17           11
    0  50                          21           18

LOOPS  LABEL      INDEX       FROM-TO     LENGTH     PROPERTIES
   13  20         L             7 10         6B       INSTACK
   35  50         L            18 21         4B       INSTACK
```

```
      SUBROUTINE SORT       74/74   OPT=1                         FTN 4.5+414        06/01/76  14.04.49        PAGE     2

COMMON BLOCKS   LENGTH     MEMBERS - BIAS NAME(LENGTH)
      D          1200                0 T       (600)           600 PP      (600)

STATISTICS
  PROGRAM LENGTH                 23318     1241
  CM LABELED COMMON LENGTH       22608     1200
```

```
SUBROUTINE GOODFIT    74/74   OPT=1                          FTN 4.5+414      06/01/76  14.04.49      PAGE     1

   1                 SUBROUTINE GOODFIT(Y,YI,N,M,J)
                     INTEGER FLAG                                             GOODFIT      2
                     COMMON/A/IND,FLAG,IPRAM,DEV                              GOODFIT      3
                     COMMON/E/GAUS(3),S                                       GOODFIT      4
   5                 DIMENSION Y(600),YI(600)                                 GOODFIT      5
                     IF(FLAG.EQ.2)  RETURN                                    GOODFIT      6
                     SUM=0.                                                   GOODFIT      7
                     DO 10 I=1,N                                              GOODFIT      8
                     YL=ALOG10(Y(I))                                          GOODFIT      9
  10                 YIL=ALOG10(YI(I))                                        GOODFIT     10
                     SUM=SUM+(YL-YIL)**2                                      GOODFIT     11
                10   CONTINUE                                                 GOODFIT     12
                     GO TO (20,30,40),J                                       GOODFIT     13
                20   GAUS(1)=SUM/(N-M)                                        GOODFIT     14
  15                 RETURN                                                   GOODFIT     15
                30   GAUS(2)=SUM/(N-M)                                        GOODFIT     16
                     RETURN                                                   GOODFIT     17
                40   GAUS(3)=SUM/(N-M)                                        GOODFIT     18
                     RETURN                                                   GOODFIT     19
  20                 END                                                      GOODFIT     20
                                                                              GOODFIT     21

CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

    13     I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.


   SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
   3  GOODFIT         1             6         15         17         19

VARIABLES       SN  TYPE               RELOCATION
   3  DEV           REAL                  A            REFS     3
   1  FLAG          INTEGER               A            REFS     2        3        6
   0  GAUS          REAL        ARRAY     E            REFS     4    DEFINED     14        16        18
  60  I             INTEGER                            REFS     9       10    DEFINED       8
   0  IND           INTEGER               A            REFS     3
   2  IPRAM         INTEGER               A            REFS     3
   0  J             INTEGER                F.P.        REFS    13    DEFINED      1
   0  M             INTEGER                F.P.        REFS    14       16       18    DEFINED       1
   0  N             INTEGER                F.P.        REFS     8       14       16       18    DEFINED       1
   3  S             REAL                  E            REFS     4
  57  SUM           REAL                               REFS    11       14       16       18    DEFINED       7       11
   0  Y             REAL        ARRAY      F.P.        REFS     5        9    DEFINED      1
   0  YI            REAL        ARRAY      F.P.        REFS     5       10    DEFINED      1
  62  YIL           REAL                               REFS    11    DEFINED     10
  61  YL            REAL                               REFS    11    DEFINED      9

EXTERNALS           TYPE   ARGS        REFERENCES
      ALOG10        REAL      1 LIBRARY     9          10
```

```
      SUBROUTINE GOODFIT    74/74   OPT=1                                FTN 4.5+414       06/01/76  14.04.49       PAGE     2

STATEMENT LABELS              DEF LINE   REFERENCES
    0  10                         12          8
   42  20                         14         13
   46  30                         16         13
   52  40                         18         13

LOOPS  LABEL     INDEX      FROM-TO     LENGTH     PROPERTIES
   21  10      * I            8 12        12B                  EXT REFS

COMMON BLOCKS    LENGTH      MEMBERS - BIAS NAME(LENGTH)
        A           4                 0 IND     (1)                  1 FLAG    (1)                  2 IPRAM  (1)
                                      3 DEV     (1)
        E           4                 0 GAUS    (3)                  3 S       (1)

STATISTICS
  PROGRAM LENGTH                75B       61
  CM LABELED COMMON LENGTH      10B        8
```

```
SUBROUTINE GAUSS      74/74    OPT=1                      FTN 4.5+414       06/01/76  14.04.49       PAGE     1

              SUBROUTINE GAUSS
              INTEGER FLAG                                                   GAUSS      2
              COMMON/A/IND,FLAG,IPRAM,DEV                                    GAUSS      3
              COMMON/E/GAUS(3),S                                             GAUSS      4
              J=3                                                            GAUSS      5
              IF(FLAG.EQ.2)  RETURN                                          GAUSS      6
              IF(FLAG.EQ.1)  J=2                                             GAUSS      7
              GMIN=1.E300                                                    GAUSS      8
              DO 10 I=1,J                                                    GAUSS      9
              GMIN=AMIN1(GMIN,GAUS(I))                                       GAUSS     10
        10    CONTINUE                                                       GAUSS     11
              DO 15 I=1,J                                                    GAUSS     12
              IF(GMIN.EQ.GAUS(I))  L=I                                       GAUSS     13
        15    CONTINUE                                                       GAUSS     14
              WRITE(6,20)                                                    GAUSS     15
        20    FORMAT(/,/,5X,34HGAUSS CRITERION OF GOODNESS OF FIT,/,10X,     GAUSS     16
             143HTHE EQUATION WHICH BEST FITS THIS DATA IS: )                GAUSS     17
              GO TO (30,50,70),L                                             GAUSS     18
        30    WRITE(6,40)                                                    GAUSS     19
        40    FORMAT(/,30X,11HP=A*T**(-1))                                   GAUSS     20
              RETURN                                                         GAUSS     21
        50    WRITE(6,60)                                                    GAUSS     22
        60    FORMAT(/,30X,12HP=B*T**(-.5))                                  GAUSS     23
              RETURN                                                         GAUSS     24
        70    WRITE(6,80)                                                    GAUSS     25
        80    FORMAT(/,30X,22HP=A*T**(-1)+B*T**(-.5))                        GAUSS     26
              RETURN                                                         GAUSS     27
              END                                                            GAUSS     28
                                                                             GAUSS     29

CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

    18      I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.


        SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    1  GAUSS           1            6         21         24         27

VARIABLES       SN  TYPE              RELOCATION
    3  DEV          REAL                  A          REFS       3
    1  FLAG         INTEGER               A          REFS       2
    0  GAUS         REAL          ARRAY   E          REFS       4         3         6         7
  117  GMIN         REAL                             REFS       4        10        13
  120  I            INTEGER                          REFS      10        13   DEFINED         8        10
    0  IND          INTEGER               A          REFS      10      2*13   DEFINED         9        12
    2  IPRAM        INTEGER               A          REFS       3
  116  J            INTEGER                          REFS       3
  121  L            INTEGER                          REFS       9        12   DEFINED         5         7
    3  S            REAL                  E          REFS      18   DEFINED        13
                                                                4
```

```
      SUBROUTINE GAUSS      74/74   OPT=1                        FTN 4.5+414      06/01/76  14.04.49      PAGE    2

FILE NAMES        MODE
      TAPE6       FMT                    WRITES      15        19        22        25

INLINE FUNCTIONS    TYPE    ARGS          DEF LINE   REFERENCES
      AMIN1         REAL       0  INTRIN                 10

STATEMENT LABELS                 DEF LINE    REFERENCES
      0  10                          11          9
      0  15                          14         12
     55  20        FMT               16         15
     41  30                          19         18
     73  40        FMT               20         19
     44  50                          22         18
    101  60        FMT               23         22
     47  70                          25         18
    110  80        FMT               26         25

LOOPS  LABEL      INDEX      FROM-TO     LENGTH     PROPERTIES
   13  10           I          9 11         4B       INSTACK
   22  15           I         12 14         4B       INSTACK

COMMON BLOCKS    LENGTH      MEMBERS - BIAS NAME(LENGTH)
       A            4                  0 IND     (1)             1 FLAG   (1)             2 IPRAM  (1)
                                       3 DEV     (1)
       E            4                  0 GAUS    (3)             3 S      (1)

STATISTICS
  PROGRAM LENGTH                 122B        82
  CM LABELED COMMON LENGTH        10B         8
```

APPENDIX C

```
FUNCTION SAB        74/74    OPT=1                          FTN 4.5+414       06/01/76  14.04.49       PAGE      1

                  FUNCTION SAB(N,A,B)                                                 SAB          2
                  COMMON/D/T(600),PP(600)                                             SAB          3
                  SUM=0.                                                              SAB          4
                  NN=N                                                                SAB          5
                  AA=A                                                                SAB          6
                  BB=B                                                                SAB          7
                  DO 10 I=1,NN                                                        SAB          8
                  ARG=AA*(T(I)**(-1))+BB*(T(I)**(-.5))                                SAB          9
                  AL=1.0E+100                                                         SAB         10
                  IF(ARG.GT.0.)  AL=ALOGIO(ARG)                                       SAB         11
                  PL=ALOG10(PP(I))                                                    SAB         12
                  SUM=SUM+(PL-AL)**2                                                  SAB         13
               10 CONTINUE                                                            SAB         14
                  SAB=SUM                                                             SAB         15
                  RETURN                                                              SAB         16
                  END                                                                 SAB         17


      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    4  SAB              1          15

VARIABLES       SN   TYPE               RELOCATION
     0  A            REAL                  F.P.          REFS        5   DEFINED       1
    53  AA           REAL                                REFS        8   DEFINED       5
    57  AL           REAL                                REFS       12   DEFINED       9         10
    56  ARG          REAL                                REFS     2*10   DEFINED       8
     0  B            REAL                  F.P.          REFS        6   DEFINED       1
    54  BB           REAL                                REFS        8   DEFINED       6
    55  I            INTEGER                             REFS      2*8        11   DEFINED       7
     0  N            INTEGER               F.P.          REFS        4   DEFINED       1
    52  NN           INTEGER                             REFS        7   DEFINED       4
    60  PL           REAL                                REFS       12   DEFINED      11
  1130  PP           REAL        ARRAY    D              REFS        2        11
    50  SAB          REAL                             DEFINED       14
    51  SUM          REAL                                REFS       12        14   DEFINED       3          12
     0  T            REAL        ARRAY    D              REFS        2       2*8

EXTERNALS           TYPE    ARGS         REFERENCES
       ALOG10       REAL     1 LIBRARY       10        11

STATEMENT LABELS               DEF LINE    REFERENCES
    0  10                          13          7

LOOPS  LABEL     INDEX      FROM-TO     LENGTH     PROPERTIES
   15  10      * I            7 13        25B                  EXT REFS

COMMON BLOCKS    LENGTH      MEMBERS - BIAS NAME(LENGTH)
       D          1200                  0 T       (600)              600 PP      (600)

STATISTICS
  PROGRAM LENGTH                 61B       49
  CM LABELED COMMON LENGTH     2260B     1200
```

```
SUBROUTINE OWNDAT     74/74    OPT=1                    FTN 4.5+414       06/01/76  14.04.49       PAGE     1

           SUBROUTINE OWNDAT(NUMB)                                             OWNDAT     2
           REAL JUNC,MAN1,MAN2                                                 OWNDAT     3
           COMMON/A/ IND,FLAG,IPRAM,DEV                                        OWNDAT     4
           COMMON/D/ T(600),PP(600)                                            OWNDAT     5
           COMMON/F/IPLOT,ISEM,ITYPE                                           OWNDAT     6
           COMMON/G/DEVTYP1,DEVTYP2,JUNC,MAN1,MAN2,TECH,DATEE,ISTOP            OWNDAT     7
           READ(5,10) IDENT1,IDENT2,XLAB,YLAB                                  OWNDAT     8
        10 FORMAT(2A10,10X,A10,10X,A10)                                        OWNDAT     9
           DO 30 I=1,NUMB                                                      OWNDAT    10
           READ(5,20) T(I),PP(I)                                               OWNDAT    11
        20 FORMAT(2E10.3)                                                      OWNDAT    12
        30 CONTINUE                                                            OWNDAT    13
           IF(ISTOP.EQ.3)  GO TO 85                                            OWNDAT    14
           WRITE(6,40) DEV,DEVTYP1,DEVTYP2,JUNC,MAN1,MAN2,TECH,DATEE           OWNDAT    15
        40 FORMAT(5X,8HDEVICE: ,A8,3X,13HDEVICE TYPE: ,2A10,3X,                OWNDAT    16
          110HJUNCTION: ,A9,/,5X,14HMANUFACTURER: ,2A10,3X,12HTECHNICIAN: ,    OWNDAT    17
          2A10,3X,6HDATE: ,A10,/,/)                                            OWNDAT    18
           WRITE(6,50) IDENT1,IDENT2                                           OWNDAT    19
        50 FORMAT(5X,16HIDENTIFICATION: ,2A10,/,/)                             OWNDAT    20
           WRITE(6,60) XLAB,YLAB,XLAB,YLAB,XLAB,YLAB                           OWNDAT    21
        60 FORMAT(3(11X,A10,5X,A10))                                           OWNDAT    22
           WRITE(6,70)                                                         OWNDAT    23
        70 FORMAT(3(11X,25(1H-)))                                              OWNDAT    24
           CALL COLMNS(NUMB,T,PP)                                              OWNDAT    25
           WRITE(6,80)                                                         OWNDAT    26
        80 FORMAT(1H1)                                                         OWNDAT    27
        85 CONTINUE                                                            OWNDAT    28
           IF(IND.EQ.2)  GO TO 90                                              OWNDAT    29
           CALL DIRECT(NUMB,3,A,B,AE,BE,IT)                                    OWNDAT    30
           CALL WRITE(A,B,AE,BE,1,IT)                                          OWNDAT    31
           CALL GAUSS                                                          OWNDAT    32
           IF(ISTOP.EQ.1)  GO TO 88                                            OWNDAT    33
           CALL PLOTT(NUMB,NUMB,1)                                             OWNDAT    34
        88 IF(IND.EQ.1)  GO TO 100                                             OWNDAT    35
        90 CONTINUE                                                            OWNDAT    36
           CALL DIRECT(NUMB,3,A,B,AE,BE,IT)                                    OWNDAT    37
           CALL WRITE(A,B,AE,BE,2,IT)                                          OWNDAT    38
           CALL GAUSS                                                          OWNDAT    39
           IF(ISTOP.EQ.1)  GO TO 100                                           OWNDAT    40
           CALL PLOTT(NUMB,NUMB,2)                                             OWNDAT    41
       100 CONTINUE                                                            OWNDAT    42
           RETURN                                                              OWNDAT    43
           END                                                                 OWNDAT    44


      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    3 OWNDAT          1           42

VARIABLES       SN  TYPE           RELOCATION
  267  A            REAL                          REFS      29       30       36       37
  271  AE           REAL                          REFS      29       30       36       37
  270  B            REAL                          REFS      29       30       36       37
```

```
       SUBROUTINE OWNDAT      74/74    OPT=1                              FTN 4.5+414       06/01/76  14.04.49       PAGE     2

  VARIABLES        SN   TYPE              RELOCATION
    272  BE                REAL                              REFS        29        30        36        37
      6  DATEE             REAL                     G        REFS         6        14
      3  DEV               REAL                     A        REFS         3        14
      0  DEVTYP1           REAL                     G        REFS         6        14
      1  DEVTYP2           REAL                     G        REFS         6        14
      1  FLAG              REAL                     A        REFS         3
    266  I                 INTEGER                           REFS      2*10   DEFINED         9
    262  IDENT1            INTEGER                           REFS        18   DEFINED         7
    263  IDENT2            INTEGER                           REFS        18   DEFINED         7
      0  IND               INTEGER                  A        REFS         3        28        34
      0  IPLOT             INTEGER                  F        REFS         5
      2  IPRAM             INTEGER                  A        REFS         3
      1  ISEM              INTEGER                  F        REFS         5
      7  ISTOP             INTEGER                  G        REFS         6        13        32        39
    273  IT                INTEGER                           REFS        29        30        36        37
      2  ITYPE             INTEGER                  F        REFS         5
      2  JUNC              REAL                     G        REFS         2         6        14
      3  MAN1              REAL                     G        REFS         2         6        14
      4  MAN2              REAL                     G        REFS         2         6        14
      0  NUMB              INTEGER                   F.P.    REFS         9        24        29      2*33       36      2*40
                                                          DEFINED         1
   1130  PP                REAL           ARRAY     D        REFS         4        24   DEFINED        10
      0  T                 REAL           ARRAY     D        REFS         4        24   DEFINED        10
      5  TECH              REAL                     G        REFS         6        14
    264  XLAB              REAL                              REFS      3*20   DEFINED         7
    265  YLAB              REAL                              REFS      3*20   DEFINED         7

  FILE NAMES          MODE
        TAPE5         FMT                          READS        7        10
        TAPE6         FMT                         WRITES       14        18        20        22        25

  EXTERNALS              TYPE    ARGS       REFERENCES
        COLMNS                     3            24
        DIRECT                     7            29        36
        GAUSS                      0            31        38
        PLOTT                      3            33        40
        WRITE                      6            30        37

  STATEMENT LABELS                  DEF LINE    REFERENCES
    154  10         FMT                  8           7
    165  20         FMT                 11          10
      0  30                             12           9
    202  40         FMT                 15          14
    224  50         FMT                 19          18
    241  60         FMT                 21          20
    247  70         FMT                 23          22
    255  80         FMT                 26          25
     47  85                             27          13
     64  88                             34          32
     66  90                             35          28
    101  100                            41          34        39

  LOOPS   LABEL     INDEX       FROM-TO      LENGTH      PROPERTIES
    20    30       * I            9 12        11B                     EXT REFS
```

```
      SUBROUTINE OWNDAT      74/74    OPT=1                          FTN 4.5+414       06/01/76  14.04.49        PAGE     3

COMMON BLOCKS   LENGTH      MEMBERS - BIAS NAME(LENGTH)
      A              4                 0 IND      (1)               1 FLAG    (1)                    2 IPRAM  (1)
                                       3 DEV      (1)
      D           1200                 0 T        (600)           600 PP      (600)
      F              3                 0 IPLOT    (1)               1 ISEM    (1)                    2 ITYPE  (1)
      G              8                 0 DEVTYP1(1)                 1 DEVTYP2(1)                     2 JUNC   (1)
                                       3 MAN1     (1)               4 MAN2    (1)                    5 TECH   (1)
                                       6 DATEE    (1)               7 ISTOP   (1)

STATISTICS
  PROGRAM LENGTH                  276B      190
  CM LABELED COMMON LENGTH       2277B     1215
```

```
SUBROUTINE COLMNS     74/74    OPT=1                  FTN 4.5+414      06/01/76  14.04.49        PAGE      1

            SUBROUTINE COLMNS(KPTS,X,Y)                                     COLMNS    2
            DIMENSION X(1),Y(1)                                             COLMNS    3
      40    INC=KPTS/3                                                      COLMNS    4
            IK=MOD(KPTS,3)                                                  COLMNS    5
            ICOL=INC+1                                                      COLMNS    6
            IF(IK.EQ.0)  GO TO 50                                           COLMNS    7
            IF(IK.EQ.1)  GO TO 70                                           COLMNS    8
            IF(IK.EQ.2)  GO TO 80                                           COLMNS    9
      50    WRITE(6,60) (X(I),Y(I),X(I+INC),Y(I+INC),X(I+2*INC),Y(I+2*INC), COLMNS   10
           1I=1,INC)                                                        COLMNS   11
      60    FORMAT(3(11X,1PE11.3,3X,1PE11.3))                               COLMNS   12
            GO TO 90                                                        COLMNS   13
      70    WRITE(6,60) (X(I),Y(I),X(I+ICOL),Y(I+ICOL),X(I+2*ICOL-1),       COLMNS   14
           1Y(I+2*ICOL-1),I=1,INC)                                          COLMNS   15
            WRITE(6,60) X(ICOL),Y(ICOL)                                     COLMNS   16
            GO TO 90                                                        COLMNS   17
      80    WRITE(6,60) (X(I),Y(I),X(I+ICOL),Y(I+ICOL),X(I+2*ICOL),         COLMNS   18
           1Y(I+2*ICOL),I=1,INC)                                            COLMNS   19
            WRITE(6,60) X(ICOL),Y(ICOL),X(2*ICOL),Y(2*ICOL)                 COLMNS   20
      90    CONTINUE                                                        COLMNS   21
            RETURN                                                          COLMNS   22
            END                                                             COLMNS   23


      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
   3  COLMNS          1             21

VARIABLES      SN  TYPE            RELOCATION
  230  I           INTEGER                         REFS      6*9     6*13    6*17   DEFINED     9      13      17
  227  ICOL        INTEGER                         REFS      4*13    2*15    4*17     4*19   DEFINED     5
  226  IK          INTEGER                         REFS      6       7       8      DEFINED     4
  225  INC         INTEGER                         REFS      5       5*9     13       17     DEFINED     3
    0  KPTS        INTEGER              F.P.       REFS      3       4     DEFINED     1
    0  X           REAL       ARRAY     F.P.       REFS      2       3*9     3*13     15       3*17    2*19
                                                DEFINED      1
    0  Y           REAL       ARRAY     F.P.       REFS      2       3*9     3*13     15       3*17    2*19
                                                DEFINED      1

FILE NAMES        MODE
      TAPE6       FMT                    WRITES      9       13      15      17      19

INLINE FUNCTIONS    TYPE    ARGS         DEF LINE   REFERENCES
      MOD         INTEGER    2  INTRIN                  4

STATEMENT LABELS               DEF LINE    REFERENCES
    0  40          INACTIVE        3
   26  50                          9          6
  157  60       FMT               11          9       13      15      17      19
   52  70                         13          7
  105  80                         17          8
  142  90                         20         12       16
```

```
      SUBROUTINE COLMNS      74/74   OPT=1                          FTN 4.5+414       06/01/76  14.04.49        PAGE      2

LOOPS  LABEL      INDEX       FROM-TO     LENGTH     PROPERTIES
   31           * I              9 9          17B                EXT REFS
   55           * I            13 13          17B                EXT REFS
  110           * I            17 17          17B                EXT REFS

STATISTICS
  PROGRAM LENGTH                    257B       175
```

APPENDIX C

```
SUBROUTINE CHANGE     74/74    OPT=1                          FTN 4.5+414       06/01/76  14.04.49       PAGE      1

                   SUBROUTINE CHANGE(NUMB,XLAB,YLAB,X,Y)
                   COMMON/D/ T(600),PP(600)                                 CHANGE      2
                   DIMENSION XTITLE(3),YTITLE(3),X(600),Y(600)              CHANGE      3
                   DIMENSION XLAB(3),YLAB(3)                                CHANGE      4
                   DATA XTITLE/3*1H /,YTITLE/3*1H /                         CHANGE      5
                   XTITLE(1)=5H                                             CHANGE      6
                   XTITLE(2)=10HPULSE WIDT                                  CHANGE      7
                   XTITLE(3)=10HH                                           CHANGE      8
                   YTITLE(1)=10H                                            CHANGE      9
                   YTITLE(2)=10HPOWER                                       CHANGE     10
                   DO 5 I=1,3                                               CHANGE     11
                   XLAB(I)=XTITLE(I)                                        CHANGE     12
                   YLAB(I)=YTITLE(I)                                        CHANGE     13
               5   CONTINUE                                                 CHANGE     14
                   DO 10 I=1,NUMB                                           CHANGE     15
                   X(I)=T(I)                                                CHANGE     16
                   Y(I)=PP(I)                                               CHANGE     17
              10   CONTINUE                                                 CHANGE     18
                   RETURN                                                   CHANGE     19
                   END                                                      CHANGE     20
                                                                            CHANGE     21


     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
   3  CHANGE          1            19

VARIABLES      SN  TYPE            RELOCATION
   42  I            INTEGER                          REFS      2*12      2*13      2*16      2*17   DEFINED      11      15
    0  NUMB         INTEGER                 F.P.     REFS       15    DEFINED        1
 1130  PP           REAL        ARRAY   D            REFS        2        17
    0  T            REAL        ARRAY   D            REFS        2        16
    0  X            REAL        ARRAY       F.P.     REFS        3    DEFINED        1        16
    0  XLAB         REAL        ARRAY       F.P.     REFS        4    DEFINED        1        12
   43  XTITLE       REAL        ARRAY                REFS        3        12    DEFINED        5        6        7       8
    0  Y            REAL        ARRAY       F.P.     REFS        3    DEFINED        1        17
    0  YLAB         REAL        ARRAY       F.P.     REFS        4    DEFINED        1        13
   46  YTITLE       REAL        ARRAY                REFS        3        13    DEFINED        5        9       10

STATEMENT LABELS                 DEF LINE   REFERENCES
    0  5                            14         11
    0  10                           18         15

LOOPS  LABEL     INDEX     FROM-TO    LENGTH    PROPERTIES
   20  5         I          11 14       38B      INSTACK
   31  10        I          15 18       38B      INSTACK

COMMON BLOCKS    LENGTH     MEMBERS - BIAS NAME(LENGTH)
      D           1200               0 T      (600)            600 PP     (600)

STATISTICS
  PROGRAM LENGTH                    51B      41
  CM LABELED COMMON LENGTH        2260B    1200
```

APPENDIX D.--SAMPLE INPUT WHEN ISEM = 0

Sample input data are listed when all of the data in card sets 3 and 4 are used.

```
**********************************************************************************
          1         2         3         4         5         6         7         8
**********************************************************************************

      1         3                      2                      1          1
 10IN3600  DIODE                C-A       FAIRCHILD          R.PARSONS 7-23-73
03IN3600
00101 10.000E-6   100.       100.          0.    10.000E-6      1.0
    1.0      160.       160.      0.00E       0.00E  C+
00102 10.000E-6   110.       105.          .15  10.000E-6      1.0
    1.0      160.       160.      0.00E       0.00E  C+
00103 10.000E-6   120.       115.          .60   2.2  E-6      1.0
    0.       160.         0.      0.00E       0.00E  C+
06IN3600
00201 10.000E-6    60.000     60.          0.000 10.000E-6      .300
    .300      92.        92.      0.00E       0.00E  C+
00202 10.000E-6    70.        70.          0.    10.   E-6      .3
    .3        92.        92.        . E         . E  C+
00203 10.    E-6    80.        80.          0.    10.   E-6     0.3
    .3        92.        92.        . E         . E  C+
00204 10.    E-6    90.        90.          0.    10.   E-6     0.3
    0.3       92.        92.        . E         . E  C+
00205 10.    E-6   100.        80.          1.3    2.0  E-6      .3
    .3        92.        92.        . E         . E  C+   BRKDWN NO VZ CHG
00206 10.    E-6   110.        90.          2.2     .8  E-6      .3
    .3        92.         4.        . E         . E  C+
03IN3600
00301 10.    E-6    80.        80.          0.0   10.   E-6      .3
    .3        90.        90.        . E         . E  C+
00302 10.    E-6    90.        90.          0.    10.   E-6      .3
    .3        90.        90.        . E         . E  C+
00303 10.    E-6   100.        95.          0.7    3.0  E-6      .3
    .3        90.         0.        . E         . E  C+
04IN3600
00401 10.    E-6    80.        80.          0.0   10.0  E-6      .3
    .3        98.        98.        . E         . E  C+
00402 10.    E-6    90.        90.          0.0   10.   E-6      .3
    .3        98.        98.        . E         . E  C+
00403 10.    E-6   100.       100.          0.0   10.   E-6      .3
    .3        98.        98.        . E         . E  C+
00404 10.    E-6   110.       105.          1.0    1.9  E-6      .3
    .0        98.         0.        . E         . E  C+
03IN3600
00501 10.    E-6    80.        80.          0.0   10.0  E-6      .3
    .3        86.        86.        . E         . E  C+
00502 10.    E-6    90.        85.           .6    1.2  E-6      .3
    .3        86.        83.        . E         . E  C+BRKDWN DEVICE NO CG
00503 10.    E-6   100.        90.          1.8    1.2  E-6      .3
    .3        86.        12.        . E         . E  C+
03IN3600
00601 10.    E-6    80.        80.          0.0   10.   E-6      .3
    .3        86.        86.        . E         . E  C+
00602 10.    E-6    90.        90.          0.0   10.   E-6      .3
    .3        86.        86.        . E         . E  C+
00603 10.    E-6   100.        90.          1.0    1.2  E-6      .3
    .0        86.         0.0       . E         . E  C+
```

APPENDIX D

```
***************************************************************************************
          1         2         3         4         5         6         7         8
***************************************************************************************


041N3600
00701 10.    E-6    80.          80.           0.0   10.   E-6        .3
       .3     86.         86.          .  E         .  E  C+
00702 10.    E-6    90.          90.           0.0   10.   E-6        .3
       .3     86.         86.          .  E         .  E  C+
00703 10.    E-6   100.          95.            .4   2.7   E-6        .3
       .3     86.         86.          .  E         .  E  C+
00704 10.    E-6   100.          90.           1.2    .8   E-6        .3
       .3     86.         17.          .  E         .  E  C+
051N3600
00801 10.    E-6    80.          80.           0.0   10.   E-6        .3
       .3     88.         88.          .  E         .  E  C+
00802 10.    E-6    90.          90.           0.0   10.   E-6        .3
       .3     88.         88.          .  E         .  E  C+
00803 10.    E-6   100.         100.           0.0   10.0  E-6        .3
       .3     88.         88.          .  E         .  E  C+
00804 10.    E-6   110.         110.           0.0   10.   E-6        .3
       .3     88.         88.          .  E         .  E
00805 10.    E-6   118.         105.           1.2   1.0   E-6        .3
       .3     88.         10.          .  E         .  E  C+
041N3600
00901  5.0   E-6    80.          80.           0.0   5.0   E-6        .3
       .3     93.         93.          .  E         .  E  C+
00902  5.0   E-6    90.          90.           0.0   5.0   E-6        .3
       .3     93.         93.          .  E         .  E  C+
00903  5.0   E-6   100.          95.            .6   2.8   E-6        .3
       .3     93.         93.          .  E         .  E  C+
00904  5.0   E-6   112.         100.            .9    .9   E-6        .3
       .2     93.         0.0          .  E         .  E  C+
041N3600
01001  5.0   E-6    80.          80.           0.0   5.0   E-6        .3
       .3     93.         93.          .  E         .  E  C+
01002  5.0   E-6    90.          90.           0.0   5.0   E-6        .3
       .3     93.         93.          .  E         .  E  C+
01003  5.    E-6   100.          97.            .2   1.1   E-6        .3
       .3     93.         93.          .  E         .  E  C+
01004  5.0   E-6   110.         103.            .9   1.8   E-6        .3
       .3     93.         8.0          .  E         .  E  C+
```

APPENDIX E.--SAMPLE INPUT WHEN ISEM = 1

Sample input data are listed when only pulse width versus power data on card set 5 are used.

```
****************************************************************************************
          1         2         3         4         5         6         7         8
****************************************************************************************

          1         2                   2                             1         1
 10IN3600  DIODE                C-A      FAIRCHILD                 R.PARSONS 7-23-73
REVERSE FAILURE                PULSE WDTH           POWER
  .800E-06   .110E+03
  .800E-06   .200E+03
  .900E-06   .900E+02
  .100E-05   .130E+03
  .120E-05   .900E+02
  .120E-05   .160E+03
  .180E-05   .930E+02
  .190E-05   .110E+03
  .220E-05   .690E+02
  .300E-05   .670E+02
```

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